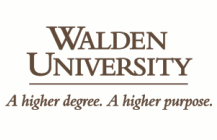

2019

Teachers' Perceptions of the Sustainability of Mathematics and Science Partnership Professional Development

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This is to certify that the doctoral study by

Robert Harold Alt

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Mary Ramirez, Committee Chairperson, Education Faculty
Dr. Tina Pitt, Committee Member, Education Faculty
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2019

Abstract

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by

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MA, Buffalo State College, 2009

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Project Study Submitted in Partial Fulfillment

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Abstract

The sustainability of improved pedagogy gained through professional development (PD) of mathematics teachers has undergone little empirical study. In a midsized urban school district in the Northeastern United States, all high school mathematics teachers attended a 3-year mandatory PD program. Although an external evaluator studied this program immediately after completion, there had been no longitudinal study of the perceptions of its participants regarding the sustained benefits of the program. This qualitative study offered a follow-up study of the participants in the Math and Science Partnership (MSP) PD program to provide insight to administrators regarding the sustainability of benefits gained through the MSP program. The conceptual framework for the study consisted of Desimone's model for evaluating PD and Kleining's framework of systematic exploration and inquiry. The participants (N =7) were asked about their perceptions of the value, applicability, longevity, and efficacy of their MSP PD and their suggestions to improve the program. Data were organized and analyzed using Patton's semistructured systematic framework to reveal general consensus as well as anecdotal evidence. The perceptions of the mathematics teachers provided pertinent information that administrators could use to determine the format of future PD. Teachers participating in this study indicated that having a college professor present a combination of content knowledge and pedagogy skills made the MSP program highly effective and long-lasting. Using this feedback, district leaders could institute improved PD, giving their teachers the skill and knowledge to lift their students academically. Closing the mathematics achievement gap may open employment and college opportunities to students which allow them to escape poverty and lead more successful lives.

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Table of Contents

Section 1: The Problem

The Local Problem

Addington Public Schools (APS), a pseudonym for a school district in the Northeastern United States, enlisted all its mathematics teachers in a 3-year, mandatory professional development (PD) program. These monthly all-day sessions were presented by professors from a local university in conjunction with the Mathematics and Science Partnership (MSP), a federally funded initiative to support collaborative PD of mathematics and science teachers. Although the program was evaluated immediately after completion by Roden (2013a) , there has been no follow-up study of the perceptions of its participants regarding the sustained benefits of the program.

At the time this study was conducted, Addington was a city in decline but bracing for revival. In 1970, the city offered over 50,000 jobs in heavy industry, but by 2009 there were little more than 10,000 manufacturing jobs (Silverman, Yin, & Patterson, 2013). By 2015 the city was poised for rebirth as a new medical campus in the heart of the city was nearing completion, abandoned warehouses were regentrified into upscale lofts, hiring managers fora billion dollar solar panel factory were interviewing new employees, and tall construction cranes dotted the city where they had not been seen for decades (Carter, 2016). The new employment opportunities being offered in the medical corridor and the highly automated solar panel factory jobs represented the "dynamically changing economic and social systems of the 21st century" (Conley, 2014, p. 3). Only workers with advanced technical and science, technology, engineering, and mathematics (STEM) skills could compete in this marketplace (Honey, 2016).

APS enrolled approximately 34,000 students and had an annual budget of about $800 million. In the school year ending 2015, Addington had a 4-year graduation rate of 57%, compared to the New York State standard of 80%, and most students performed well below state standards in mathematics, especially in Grades 7-12 (New York State Department of Education, 2016). APS recognized several years before this current study that the school district was facing a growing problem: employers were demanding better educated applicants, and APS was graduating poorly educated students, particularly urban, low-income, and minority students, as indicated by Weis et al. (2015) in a study of student outcomes in Addington schools.

To prepare teachers for greater effectiveness in teaching STEM subjects, APS provided 3 years of PD for mathematics and science teachers under the MSP program (Gersten, Taylor, Keys, Rolfhus, & Newman-Gonchar, 2014). The MSP program was created in 2002 by the U.S. Department of Education as a new departure born of No Child Left Behind (NCLB) and nurtured under Race to the Top (RttT), to bolster U.S. competitiveness, particularly in math and engineering, areas of expertise desperately needed to further new technical and industrial advances (Ellison & Allen, 2018). MSP was a PD program designed by the National Science Foundation to improve the quality of STEM instruction by forging a partnership between K-12 schools and their local universities (Foster, Toma, & Troske, 2013). Foster et al. (2013) cited a report from the Government Accountability Office identifying overlapping federal expenditures to improve math instruction exceeding $3 billion by 2010.

The outlay of funds for teacher PD has been met by a call for research on the effectiveness and value of such programs. Scholarly researchers have addressed the challenges of implementing effective PD and sustaining its efficacy after cessation. Some PD programs have demonstrated short-term improvement in student outcomes, but these gains failed to persist (Eisenhart et al., 2015). Factors that directly inhibit sustainability have been difficult to identify because rigor is lacking in many current studies, leaving sustainability as a hidden but increasingly critical issue (Century, Cassata, Freeman, & Rudnick, 2012). There was therefore a general need for further study and a critical local need to collect more empirical data to find a clearer path to improving the sustainability of PD in STEM education (Bayar, 2014; Hacker, 2016; Piasta, Logan, Pelatti, Capps, & Petrill, 2015; Tricarico, Jacobs, & Yendol-Hoppey, 2015). Highly trained experts in education, such as teachers who completed the MSP training program, could offer a wealth of information through qualitative analysis of their perceptions of their MSP training and their recommendations for its improvement.

Rationale

Purpose of this Study

The intent of this study was to provide essential information to administrators that was currently lacking--an analysis of follow-up interviews with past participants in the MSP PD program--which might lead to improved PD of mathematics teachers in the future. My goal in conducting this study was to gather and analyze insights from professional educators to identify which elements of their MSP PD program were efficacious and sustained in their professional practice. This information, and additional

perceptions and suggestions, was curated in the form of a recommendation report to assist stakeholders and decision makers in designing more effective training programs leading to improved classroom instruction.

Teachers are the practitioners in the field who are directly responsible for imparting knowledge, encouraging participation, and inspiring effort on the part of their students. They are the recipients of PD that is provided by governments and administrations in the hope of improving student achievement. Thus, their suggestions and insights may inform administrators and help them design more effective training for mathematics teachers with longer-lasting benefit.

Research findings support that teachers have much to offer in appraising the effectiveness of their training and its value in improving student achievement. Authors of an empirical qualitative study of teachers who finished a multiyear training program, for instance, identified six components they found most effective: matching of training to teachers' needs, matching of training to school needs, teacher involvement in the planning of training, adequate participation opportunities, long-term engagement, and high-quality instructors (Bayar, 2014). I used a direct interview approach to gather reliable information from those teachers actively engaged in the training process and the resulting classroom teaching process. The findings could provide guidance to school districts and government agencies that underwrite PD opportunities for teachers; using study findings, leaders may be able to plan more effective programs with greater sustainability and more potent improvement in teacher effectiveness.

Evidence of the Problem at the Local Level

In their study of eight urban high schools in Denver, Colorado, and Addington, New York, Eisenhart et al. (2015) found that STEM PD programs introduced to improve classroom instruction in these areas were modestly successful initially but failed to maintain these gains. Stakeholders who design, implement, and fund PD programs for teachers need more complete information in order to execute more effective and longer lasting programs to improve classroom instruction in STEM fields (Blank, 2013; H. Hill, Beisiegel, & Jacob, 2013). Elliott (2012) decried the "lack of professional development set-aside funds to support training needed to increase instructional capacity and skills" (p. 7). These resources indicated a local need for more information regarding training of mathematics teachers.

I conducted a phone interview with John Roden, the professional evaluator of the MSP program that was administered in APS. During the interview, Roden detailed the careful pretesting and posttesting procedures he employed, as well as the follow-up classroom visits he made, to assess the immediate results of this PD program at the end of each of the 3 years of training. Roden (personal communication, July 16, 2016) decried the lack of a follow-up study to assess the sustainability of the program as manifested in the classroom.

I intended to fill this gap in practice by gathering and analyzing empirical qualitative data from past participants in the MSP program in APS to examine their perceptions of the effect of their training on their teaching and their suggestions to improve PD. APS could use this information to revise their PD programs to be more

effective in improving classroom instruction over a longer period. The project to be developed based on the findings of this study, including recommendations in the words of their own teachers, could provide significant impetus to improving teacher training in APS.

Evidence of the Problem Nationally

Darling-Hammond, Wei, Andree, Richardson, and Orphanos (2009) collected and analyzed data comparing PD of teachers in the United States and teachers abroad. They reported that U.S. teachers found that much of their professional training was of little value; however, 59% of U.S. teachers found content-related training to be effective or very effective. A status report for the National Staff Development Council listed several characteristics of effective PD perceived by the teachers they interviewed; the characteristics included intensity, persistence, connection to practice, and focus on content (Wei, Andree, & Darling-Hammond, 2009). Aligned with this need to reinforce content knowledge, the nationwide MSP program, funded by the National Science Foundation, was designed to provide rigorous, content-based PD (Foster et al., 2013). The purpose of my study was to seek insights from teachers who participated in the full 3-year MSP program about which elements of their MSP PD program were effective and sustained in their professional practice.

As the MSP initiative was being rolled out nationally, the authors of a study of urban turn-around schools commissioned by Arne Duncan, secretary of the U.S. Department of Education, found that only 47 of 1,037 elementary schools were able to demonstrate sustained achievement after PD, and suggested that “few schools across the

nation are likely to be making quick gains that are sustained over an appreciable period of time" (Aladjem et al., 2010, p. 19). This empirical data collected before the start of the MSP initiative painted a grave picture of the success and sustainability of previous mathematics PD programs. The local problem identified by APS was indeed felt in many urban schools throughout the United States.

Effect of the Problem on Individual Schools

A study of teacher PD in New Jersey indicated that teachers in failing schools perceived that their training did not address their specific needs (Wiggins, 2017). This is a pressing problem in APS, where several schools struggle to meet Adequate Yearly Progress (AYP; Weis et al., 2015). An important element of President George W. Bush's NCLB Act, implemented in 2002, is the requirement that "if schools or districts receive federal funds, such as Title I funds due to the number of low-income students, they must meet AYP in order to maintain these federal funds" (Pruitt & Bowers, 2014, p. 2). The requirements of achieving AYP include testing at least 95% of the student body and meeting specified targets for proficiency, attendance, and graduation (Yell, Katsiyannas, & Shiner, 2006).

This AYP stipulation was a constant source of stress and concern for teachers and administrators in the urban school where I taught mathematics. Not achieving AYP led to reduced funding, forced transfer of teachers and administrators, and closing persistently underperforming schools (Childs & Russell, 2017). This mandate was particularly difficult to achieve in schools with predominantly minority student populations (Weis et al., 2015). Urban school administrators were strained even more, as the AYP standards

persisted under President Obama's RttT, where federal funds were withheld from schools that did not achieve certain statistical targets, even though data demonstrated that these targets were unrealistic for urban schools (Stern, 2013). Improved teaching that led to improved student scores might alleviate this persistent stress.

Definitions of Terms

Adequate Yearly Progress (*AYP)*: The amount of annual accomplishment growth to be expected by students in a particular school, district, or state in the U.S. federal accounting system, to comply with the requirements of NCLB (Markowitz, 2018)

Efficacy: A measure of effectiveness under controlled conditions (Lloyd, Veal, & Howell, 2016).

Heuristic research: A systematic discovery method used in qualitative research and developed in the 1980s by Kleining and Witt (2000), which allows for discursive interactions between the researcher and research subjects (Naber, 2015).

Mathematics and Science Partnerships (MSP) program: A federally funded grant program that funds cooperative training programs between STEM departments at universities and public school districts (US Department of Education, 2017).

Knowledge integration: The harmonization and synthesis of knowledge from different individuals, disciplines, and domains to create new knowledge (Berggren, 2017).

No Child Left Behind Act of 2001 (NCLB): The act of the U.S. Congress that reauthorized the Elementary and Secondary Education Act; it included Title I provisions pertaining to disadvantaged students (Markowitz, 2018).

Professional development (PD): Teacher training programs whose goal is to improve teachers' content knowledge and pedagogy, leading to sustained improved outcomes in the classroom (King, 2014).

The Race to the Top Fund (RttT): A fund that provides competitive grants to encourage and reward states that are creating the conditions for education innovation and reform (McGuinn, 2012).

Self-efficacy: A belief of self-competence held by a teacher, fostered by a feeling of mastery, which often leads to better academic response from students (Bandura, 1977; Carney, Brendefur, Thiede, Hughes, & Sutton, 2016).

Sustainability: The achievement of improved student outcomes or improved teacher pedagogy as a result of PD on a continuing basis (Sarama, Clements, & Wolfe, 2015, p. 427).

Significance of the Study

Students in many schools in the United States performed below international standards as measured by the 2012 Trends in International Mathematics and Science Study international assessment of mathematics and science at the fourth and eighth grades (Carnoy, Khavenson, & Ivanova, 2015; Mullis, Martin, Foy, & Arora, 2012). The study revealed the mathematics achievement gap between the United States and several of its major trading partners. The United States was at risk because the burgeoning global economy was driven by a more educated workforce, and its education system was not keeping pace with the growing demand (Sparapani, Perez, Gould, Hillman, & Clark, 2014).

Both President George H. W. Bush's NCLB education plan and President Obama's competitive grant program, RttT, required documented improvement in student outcomes (Markowitz, 2018; McGuinn, 2012; Stern, 2013). Ongoing PD of teachers was a common approach employed by school districts to achieve these goals, based on the assumption that greater subject content knowledge and updated pedagogical techniques would be transferred to the classroom, and in turn improve classroom instruction (Berk et al., 2014; Culpepper, 2014; Oonk, Verloop, & Gravemeijer, 2015; Ripley, 2016; Sandholtz & Ringstaff, 2013). The desired improved classroom instruction might only result from effective and sustainable PD.

It is important for leaders of school districts and state governments to consider whether the time, effort, and expense of PD continues to improve teacher performance for a period of time after teacher training ends. Developing countries outside the United States have found that improved PD of teachers yielded high returns on investment, second only to expenditures on instructional technology (McEwan, 2015). This model can be followed if administrators can identify and implement effective PD models.

PD of teachers is an expense for school districts, which requires additional pay for teachers or their substitutes while they are training, as well as the cost of administering the training programs (Archibald, Coggshall, Croft, & Goe, 2011; Foster et al., 2013). School administrators and public policy makers have demanded data on how their finite resources are bearing results in the classroom (Foster et al., 2013; Sriraman, 2013). More study is needed to determine if PD remains beneficial and cost effective after training ends (Sarama et al., 2015; Wagner, 2014). To this end, Banilower, Heck, and Weiss

(2007) identified the important role that PD plays in the education system and how crucial it is to investigate the sustained efficacy of these programs in terms of their benefit and their cost, but longitudinal financial data are sparse in research literature.

In 2011, as the MSP program was being inaugurated in APS, Archibald et al. (2011) released a comprehensive report identifying teacher PD as the most important but the most inadequately implemented teacher support system; they focused on the difficulty and dire necessity of evaluating the long-term success of a program from the perspective of return on financial investment. Archibald et al. cited a 2007 cost-benefit analysis by Villar and Strong of a school district in which the 5-year rate of return was $1.88 per dollar spent. Villar and Strong attributed the rate of return to monetizing the benefits of reduced staff turnover and improved teacher effectiveness (as cited in Archibald et al., 2011).

Each school district participating in the MSP PD program had the autonomy to develop its own training and assessment regimen, but all programs shared the common national goal of improving mathematics and science teaching and learning (Heaton & Smith, 2013). The most direct evidence of sustained improvement in teaching was gathered by persistent classroom observations, which are time consuming and costly (Sayler et al., 2013). Follow-up classroom visits immediately after cessation of training were performed as part of the evaluation of the MSP program examined in this study, but not subsequently. Although persistent professional classroom observations may be economically unfeasible, Roden stated that valuable qualitative data regarding

sustainability may still be collected by interviewing participants 3 or more years after the program's end.

Research Questions

Follow-up studies of PD programs for teachers have been sparse, primarily due to the expense of extended evaluation of PD programs (Archibald et al., 2011). Because I posed questions concerning human learning and performance, I concluded that they would best be studied under the framework of qualitative research (see Creswell, 2012). The MSP program is a federally funded, nationwide program, but it is administered locally by each school district (Kutaka et al., 2017). The qualitative data collected from responses to these research questions should provide information of value to APS.

The central question of this study was, "What are the perceptions of teachers who participated in the MSP PD program regarding the value, applicability, longevity, and efficacy of their training 3 years or more after attending these sessions?" Research questions to address this central question were as follows:

RQ1: Regarding value, how do teachers who participated in the MSP PD program perceive the value of the program as related to their personal effort, time away from class, preparation of work for their substitute teacher, travel to another location, and cost to the school and taxpayer?

RQ2: Regarding applicability, how do teachers who participated in the MSP PD describe to what extent and in what fashion their new learning was related, pertinent, and significant to the curriculum they teach?

RQ3: Regarding longevity, how do teachers who participated in the MSP PD describe to what extent the benefits of training endured, and to what degree?

RQ4: Regarding efficacy, what strategies do teachers who participated in the MSP PD program describe as improving their content knowledge and pedagogy?

RQ5: Regarding improvement, what improvements do teachers who participated in the MSP PD recommend regarding the MSP program, or PD in general?

This qualitative approach to inquiry provided a broad basis of information upon which to present findings and suggestions to APS administrators leading to improved PD of their mathematics teachers.

Review of the Literature

Methods of Literature Search

My search for literature pertaining to the local problem of the lack of follow-up study of the MSP training program in APS, as well as supporting and related topics, was accomplished by searching Google Scholar, Google Books, Walden University Library, ERIC, ProQuest, and other databases. Key search words were *MSP*, *PD*, *resource allocation*, *content knowledge*, *pedagogy*, *program evaluation*, *academic achievement*, *Common Core*, *economic evaluation*, *education economics*, *conceptual framework*, *qualitative analysis*, *federal role in education*, *heuristic*, *instructional evaluation*, *longitudinal study*, *mathematics instruction*, *meta-analysis*, *methodology*, *online education*, *pedagogical content knowledge*, *phenomenology*, *purposeful sampling*,

teacher competency, *TIMSS*, *teacher training*, and *urban schools*. I used Google Scholar for Boolean searches.

Conceptual Framework

The conceptual framework for my examination of the effectiveness and sustainability of the MSP training program was Desimone's (2011) model of studying PD. Desimone's framework listed three sequential steps common to successful PD programs for teachers who attended PD sessions: teachers gain new content knowledge and teaching skills, teachers use their new content and pedagogy in their classrooms, students benefit because of their teacher's PD. The research questions selected for this study closely followed Desimone's (2011) conceptual framework of successful PD programs. Careful analysis of data should help fill the gap in understanding the long-term effectiveness of the MSP PD program as it was implemented in the classroom by participating APS teachers. APS administrators may benefit from my findings by using the perceptions of their mathematics teachers to design better PD opportunities for their faculty.

My analysis of over 400 scholarly papers provided many questions but few answers regarding the efficacy and sustainability of similar programs, with many peer-reviewed papers calling for more definitive study of efficacy and sustainability as teachers deployed their new learning in their classrooms (Antoniou, Kyriakides, & Creemers, 2015; Archibald et al., 2011; Bayar, 2014; Copur-Gencturk, 2015). One author who performed a meta-analysis for the Council of Chief State School Officers that was funded by the National Science Foundation, clearly stated that "the field lacks well-

designed, scientific studies of the relationship between teacher professional learning and the degree of improvement in subsequent student learning" (Blank, 2013, p. 51). Hopefully this study will provide some useful information.

Efficacy

Many scholarly resources discussed in which ways and to what extent PD of teachers could improve the teachers' content knowledge and pedagogy. One meta-analysis of 910 research studies specifically addressing the efficacy of mathematic PD found 643 of the research studies pertained to Grades K-12, and of those, only 32 studies followed a scholarly research design to measure effectiveness. Of the five most rigorous studies, only two found a direct, positive causative link that mathematics PD of teachers improved their students' proficiency (Gersten et al., 2014).

Several individual studies reported disparate findings. Kannenberg (2014) found that a PD program implemented in 11 public schools in California did enhance the classroom practice of many of its Common Core mathematics teachers. Another study of PD in California public schools suggested that PD of teachers had a significant effect upon their teaching and their students' outcomes, but teacher expertise, not PD, was the single most important factor (Sandholtz & Ringstaff, 2013). It is important to note that the author examined efficacy 1 year after the end of the PD program but did not assess the longer-term results.

The demand for research to identify effective PD that leads to sustainable improvement in student outcomes was not limited to the United States. A study executed in the Republic of Ireland paralleled many in the United States. King (2014) studied the

PD of teachers in the Republic of Ireland and sought to answer questions regarding the efficacy and sustainability of teacher training and how to evaluate its effect on student test scores several years after teacher training ceased. King found the expectation among administrators that effective initial planning of PD would sustainably improve student outcomes, thus making short-term and long-term evaluation of PD programs imperative to indicate if there was indeed a causative linkage between PD of teachers and their students' improved achievement. Studies in Russia, Singapore, China, Denmark, Finland, Japan, and Israel raised similar questions about the strength of causation between PD of teachers and its resultant effect on student performance (Carnoy et al., 2015; Dimmock & Yong Tan, 2013; Furlong, Cochran-Smith, & Brennan, 2013; Hairon & Dimmock, 2012; Sparapani et al., 2014).

Because the aim of improving teaching is the resultant improvement in student learning, it is important to identify features of PD that accomplish this goal. Three variables that may affect or predict successful transfer of trained skills to the classroom, and how fidelity of application of these trained skills might improve student learning outcomes, are teachers' perceptions of student achievement, teachers' understanding of innovations taught during PD, and teacher experience. Data analyses did not provide clear inferences, and were sometimes counterintuitive, leading to the researchers' conclusion that more research is needed in sustainability due to the high cost of scaling up mathematics PD programs that may not continue to result in improved student achievement (Archibald et al., 2011; Century et al., 2012; Harris & Sass, 2011; Sarama et

al., 2015). School districts have finite financial resources, which makes this information essential to applying these funds wisely.

One basic research goal is clarifying which elements of content knowledge are required for effective instruction, the lack of which would invalidate any causative link. Many previous studies have used instruments that have not been validated and shown to be reliable, leading to weak data and meaningless conclusions. An important shortcoming is the reliance of previous studies on cross-sectional data, which aggregates several confounding variables such as a teacher's content knowledge, years of experience, beliefs, and school environment. Longitudinal study was identified as a method to reduce the bias of confounding variables (Copur-Gencturk, 2015).

Applicability

Program designers and school administrators needed to know if their effort in PD of teachers leads to meaningful improvement in instruction (Desimone, 2011). Several scholarly works that I reviewed for this project examined the content knowledge and pedagogy that was featured in PD programs. Blank (2013) conducted a meta-analysis for the National Science Foundation that showed scientific evidence that PD in mathematics yielded significant positive effects on student achievement.

In contrast, Borko, Koellner and Jacobs (2014) found that novice teachers did not benefit well from PD and indicated the need to develop specific programs to address this issue. Konstantopoulos and Chung (2011) found a causative link between increased training of experienced teachers and their students' improved achievement. Carney et al. (2016) queried 4,000 mathematics teachers in Idaho after a brief PD course and found

significant improvement in teachers' attitudes, but also indicated serious limitations in their study and called for more rigorous empirical investigation.

Gomez Zwiep, and Benken (2013) investigated a large PD program for mathematics teachers and found growth in teachers' content knowledge, perceptions of mathematics, and the learning of mathematics. The authors found that a number of unique challenges have to be met for greater success in training and called for further study. Kannenberg (2014) investigated PD to prepare for the launch of Common Core State Standards (CCSS) from the perspective of the instructional leaders, and identified the gap in understanding of the successes and shortcomings of PD. The author further emphasized the need for this information to guide school districts in designing more effective training programs for teachers.

Evaluating the effectiveness of PD programs for teachers is fraught with difficulty (Zehetmeier, 2014; Zehetmeier & Krainer, 2011). Barrett, Butler, and Toma (2012) suggested that past evaluations of training programs may be subject to selection bias in that participation is often voluntary. As a result, more engaged teachers might participate and be evaluated, while less interested and less effective teachers would never be subject to the training, thusly skewing the effectiveness assessment of the program because only the best teachers would self-select to participate. Browder et al. (2012) experienced difficulty in recruiting enough participants after cessation of a program in order to apply meaningful inferential statistics, and enunciated the ethical problem of withholding treatment from students in order to maintain a control group.

McMeeking, Orsi and Cobb (2012) encountered another question regarding greater analysis reliability at the expense of practicality. The most reliable method to evaluate a PD program is to have full, uniform participation of all teachers in a particular group, such as all high school math teachers in a school district. Not all teachers belong in the same cohort, some have greater experience and education, and some teach different groups of students such as special education or gifted students. McMeeking attempted to design an evaluation program that would address this internal tension, but with limited success.

Strutchens and Martin (2013) reviewed seven MSP training programs executed in different school districts throughout the United States and found many common goals as well as differences among them. All programs shared the goal and belief that MSP training would lead to change in teachers that would result in improvement in their students' knowledge of mathematics and science. All programs included the dual focus of improving teachers' content knowledge as well as their pedagogy. They found that the variety of methodologies used as well as other parameters made it nearly impossible to evaluate and compare efficacy and sustainability of the programs. On a more positive note, Heaton and Smith (2013) found the same commonalities and disparities among a group of MSP programs, but found that some mature MSP programs did collect and analyze longitudinal quantitative data on student test results and qualitative data from teachers, and these analyses indicated student growth and positive teacher change.

Value and Return on Investment

PD entails substantial expense of time and funding; therefore, stakeholders demand to know if the results of their expenditures are long-lasting. The immediate goal of PD is self-stated; it is to develop professional teachers into better teachers, with the ultimate goal of higher student achievement (Hacker, 2016). Decision-makers needed to know if their investment in PD is yielding the desired return in the form of improved teaching.

Carney et al. (2016) indicated an important financial consideration, the scaling-up of a program. Many school districts develop their own PD programs, and some indicate short-term success. Before what appears to be a successful program is launched state-wide, at many times the expense, funders need to know if the program will have longer term benefits, thusly requiring evaluation of sustainability. On an even broader scale, Wei et al. (2009) viewed PD as a national investment in professional teachers, and analyzed the return on investment of several high-achieving nations including Finland, Sweden, Japan, United Kingdom and others. The researchers found that these high-achieving nations devoted greater funding and more learning opportunities for their teachers than did the United States, and surmised that as a result, mathematic achievement scores of U.S. students were below those of these high-achieving nations.

PD programs incur expense for which funders expect a return in the form of improved student outcomes, more effective teaching, longer lasting benefits of training, reduced teacher turnover, and less costly student instruction (Archibald et al., 2011; Banilower et al., 2007; Carney et al., 2016; Hanushek, 2011; Hilton, Hilton, Dole, &

Goos, 2015; Lavigne, 2014; Paprzycki et al., 2017; Sriraman, 2013). Several studies identified professional pride, active administrative support and participation in PD as qualities that led to increasingly positive beliefs on the part of the teacher, and greater job satisfaction and retention as a result, leading to more experienced teachers who are better equipped to lead their students to higher achievement. Lavigne (2014) cited data indicating 97% of teachers in Singapore remained in their profession after 5 years, however the United States experienced a 50% attrition rate of new teachers after 5 years. Low teacher retention was a financial drain on school systems. Lavigne found that prominent among the factors that sustained and retained new teachers was effective PD.

A school district can invest time and resources in a new teacher's training, and if that teacher leaves the profession, all is wasted. The cost of replacing a new teacher has been estimated at $8,000 to $48,000 (Darling-Hammond & Berry, 2006). In light of increasing challenges to new teachers, such as implementation of new Common Core State Standards and RttT evaluations, more research is needed to improve PD and its lasting effects on new teachers and the resultant effect on their students (Bartholomew, Papay, McConnell, & Cease-Cook, 2015; Bostic & Matney, 2013; Cochran-Smith, Piazza, & Power, 2013; Jimerson, Stein, Haddock, & Shahroozi, 2016). PD is costly, but teacher attrition is significantly more expensive, as well as disruptive and deleterious to student achievement.

Compounding this lack of definitive research is the econometric pressure of studies that indicated generally weak return on the investment of a school district's finite resources devoted to PD (Banilower et al., 2007; Carney et al., 2016; Hanushek, 2011;

Hilton et al., 2015). Many school districts and governmental agencies found this local problem the result of insufficient research into short-term benefits and more importantly, long-term sustainability (Hill et al., 2013). Foster et al. (2013) identified a void in the literature that compared teacher PD to whether resources devoted to the effort provided positive fiscal gain exceeding their costs, thus exposing a further gap in understanding if other expenditures might be more efficacious in helping students to succeed.

Several authors cited data to demonstrate the difficulty in mounting a meaningful and rigorous evaluation of PD of teachers (Garet et al., 2011; Grigg, Kelly, Gamoran, & Borman, 2013; Sayler et al., 2013). Stable schools can experience a 10% staff attrition rate, while troubled schools, the ones needing PD the most, can easily undergo 35% or higher turnover in professional staffing, leaving fewer than half of their teachers completing both years of a 2-year PD program (Hanushek, 2011). Scholarly authors also indicated an international trend towards fiscal accountability in an era of cutbacks in public spending for education. The demand of the global economy for better trained workers spurs the willingness of governments to invest in PD to achieve this goal (King, 2014; Nadelson, Seifert, Moll, & Coats, 2012; Wei et al., 2009).

APS teachers have a financial interest in the effectiveness of their training because they are also local taxpayers who do not want their tax dollars, or their professional time wasted. Insights gathered from interviews with teachers provided valuable guidance to administrators regarding the economic efficiency of the MSP training program. The MSP PD program in APS was carefully evaluated immediately after completion (Roden, 2013b), and a short-term improvement in student math

achievement was indicated (Eisenhart et al., 2015), but few follow-up interviews have been collected, with data analyzed and reported to administrators to guide their future expenditures in PD of mathematics teachers (Roden, 2016). Asking research questions regarding long-term return on investment, from the perspective of teachers, may uncover important information needed by administrators to design more cost-effective PD programs.

Longevity

APS receives federal funding under the auspices of the RttT initiative which requires evaluation of all teachers (McGuinn, 2012). Teachers who are identified as "ineffective" or "developing" must receive additional PD as part of an individualized TIP, a Teaching Improvement Plan (Hursh, 2015). Existing PD programs, such as MSP, can reduce this drain on administrative and financial resources if they remain effective over a longer period. Administrators are thusly highly motivated to learn the perceptions of their teachers to enhance the sustainability of their training programs.

Scholarly studies indicated a pressing need for longitudinal data collection of student achievement scores to ascertain the long-term sustainability of PD programs in urban school districts, such as APS (Capraro et al., 2016; Childs & Russell, 2017; Farrington, 2014; Peck & Reitzug, 2014). Black and Hispanic students, and in particular Black males, underperformed their peers in mathematics (Eisenhart et al., 2015). To involve more racial and ethnic minority students in STEM fields, funding from the National Science Foundation created MSP, between secondary teachers and universities to train and motivate STEM teachers, reduce their turnover rate, and lead them to engage

racial and ethnic minority students in STEM education. The long-term results of this initiative have not been well established and need further study (Berk et al., 2014; Eisenhart et al., 2015; Patel, Franco, Miura, & Boyd, 2012; Roden, 2016; Weis et al., 2015). This study might provide important information regarding efficacy and longevity.

Sustainability, the continuation of benefit from a training program, and the continued use of the program's key components to achieve desirable student outcomes, is an essential element to measure, but examination of sustainability was found lacking by several researchers. This lack of research on sustainability was identified as a persistent local problem because most PD programs are created locally. (Lavigne, 2014; McGuinn, 2012; Sandholtz & Ringstaff, 2016; Sarama et al., 2015; Wilson & Hayes, 2009).

Sarama et al. (2015) evaluated the fidelity and sustainability of mathematics teachers' PD based on empirical research of a random sample of 64 teachers in 26 schools. The authors defined fidelity as faithfully implementing the critical components of the training sessions, and collected data using trained observers visiting classrooms recording their observations with an instrument rated at 95% interrater reliability. The authors expected that after the cessation of PD they would find decreasing levels of academic success, but their data revealed sustained levels of success 2 years after exposure to training. In contrast, Century et al. (2012) recast the goal of mathematics and science PD as innovation implementation, noting that there was much research on immediate application of these innovations, but they agreed that there was little explicit examination of the persistence of these improvements in the classroom.

In an empirical study, Copur-Gencturk (2015) followed 21 mathematics teachers for 3 years during their master's degree program to examine the relationship between their increased knowledge and the change in their practice, using conventional testing to measure teachers' content knowledge, classroom observations following a reliable protocol, and subsequent interviews with selected teachers. The researcher listed several research limitations that led to the need for further study.

A similar study in Europe, where Kuzle and Biehler (2015) reported the results of 12 mathematics mentor teachers in Germany, provided insight into the challenges that affect the quality of PD and its longer-term transferability to other teachers. Several years ago, Germany instituted a continuous PD program in mathematics to train mentors who would subsequently multiply the benefits of this PD by training other teachers. The researchers encountered a knowledge gap in how to design high-quality courses to train mentors, identifying the need for more evaluation and retrospective analysis. They found a pressing need for improving PD of teachers in order to ease the shortage of highly qualified mathematics teachers and improve the academic success of a growing number of at-risk students.

In one case that demonstrated success with the above problem, Beth, Romero, Lummus-Robinson and Perez (2012) studied the evaluation of a secondary STEM PD program as it expanded and was replicated over the past 10 years. To gauge the fidelity of each successive replication of the original STEM program and its long-term sustainability, the researchers established a formal baseline and collected data using site visits, focus groups with teachers and stakeholders, and participant surveys at several

points during and after training. The authors found a significant and consistent improvement in teacher certification testing scores of student teachers participating in the STEM training program.

Intensive PD may improve teaching, but the expense may be prohibitive. Sandholtz and Ringstaff (2013, 2016) and (Sandholtz, Ringstaff, & Matlen, 2016) studied the sustainability of changes in teachers' self-efficacy, content knowledge, and classroom practice 2 years after a state-funded PD training program for science teachers in several selected elementary schools in rural California. The program they studied offered teachers more than 100 contact hours per year and included six-day summer institutes led by college professors and educational specialists. Teachers received additional supports throughout the year to sustain the momentum of their training. The authors noted that providing high quality, persistent, and content-intensive training over several years can be prohibitively expensive for large school districts and impractical for small rural school systems. The authors' findings "indicated a beginning pattern of decline during the 2 years after the program ended, but outcomes remained higher than before the PD" (Sandholtz et al., 2016, p. 192).

Another aspect affecting student performance was school culture and national beliefs. When a whole nation focused on academic success, persistent PD was well funded and expected for all teachers, leading to outstanding student achievement. Hairon and Dimmock (2012) explored PD of teachers in Singapore where the government views education as the key vehicle to develop the human capital that drives Singapore's outstanding economic performance. They encountered three impediments to

implementing Western-style educational techniques favored by administration: high teacher workloads, lack of research consensus defining efficacy and predicting sustainability, and the historic hierarchical system in the workplace. They found that traditional national and family dedication to education was a prime motivating force in Singapore's educational success.

PD programs are costly, and so is the process of evaluating their effectiveness (Foster et al., 2013). As a result, many programs may be assessed during and immediately after training, but few are revisited over a period of years to evaluate the sustainability of their effectiveness (Roden, 2016). Sarama et al. (2015) stressed the importance of longitudinal study to evaluate the fidelity of large projects because they are so costly, and decried the lack of follow-through in most programs. An extensive longitudinal study of the implementation of a major change in the math curriculum in California revealed that certain aspects of the program aided student progress, but some elements impeded student achievement (Cai, Wang, Moyer, Wang, & Nie, 2011). The authors reported that these findings were of great formative importance to future program planners in California.

In the state of Louisiana, Gansle, Noell and Burns (2012) collected longitudinal data regarding student achievement which allowed them to offer data and data analysis regarding teacher training and certification. The researchers acknowledged in their study the inadequate literature base examining long-term sustainability of training programs. McGuinn (2012) took a much broader approach and examined the national RttT program and found that many institutional and political obstacles impeded the long-term

sustainability of many reform initiatives, resulting in no long term improvement in student test results.

Public school administrators are stewards of the public purse as well as the academic welfare of their students. They are entrusted to exercise their careful judgement in designing, implementing, and funding PD programs for their teachers. Sustainability of the benefits of PD enhance its return on investment in terms of teacher retention (Lavigne, 2014), productivity (Villar & Strong, 2007), and improved student achievement as a result of better teaching (Kannenberg, 2014). The purpose of my study was to seek insights from APS teachers who participated in the full 3-year MSP program revealing which elements of their MSP PD program were effective and sustained in their professional practice Using the findings of my study, I intended to provide necessary information to assist APS administrators in making informed decisions about PD of their teachers.

Knowledge Integration of Professional Development

Effective PD must frame an intellectually safe environment, where professional teachers are free to exchange ideas, share information, and constructively critique the work of their peers (Gerard, Varma, & Corliss, 2011). Expert trainers must model the pedagogy they wish to develop in their students and allow their teacher-students to practice this model as well, bringing together content and pedagogy as one integrated skill. Knowledge integration is the conceptual framework of coordinating and recombining knowledge from all participants to create new knowledge (Berggren, 2017). Pennington (2016) characterized this conceptual approach as the "ability to learn each

other's perspectives, participatory processes, and flexible, adaptive problem formulation" (p. 300). This knowledge integration framework is an essential element of Desimone's (2011) active participation model, the conceptual framework of this study.

The construction of successful PD programs includes both the content of the program and its method of delivery. Effective PD of mathematics teachers is generally considered an essential component in improving student outcomes, and much effort and study has been devoted to the content of teacher training courses and ongoing PD (Banilower et al., 2007). Borko et al. (2014) added to this framework by emphasizing the role of the training facilitator, who must model desired pedagogy, instill new content knowledge, and develop a culture of open exchange of knowledge. An effective program must also encourage the active participation of its recipient teachers and allow collaboration among professionals (Brodie & Shalem, 2011).

Desimone and Borko have published often-cited research in the field of PD of teachers. Borko's (2004) research constructs a conceptual framework from a psychological perspective, "using psychological conceptual frameworks and the individual as the unit of analysis, researchers can study students' activities as individuals and their evolving knowledge and understanding" (p. 4). The author linked the elements into a system for PD that includes the overarching context of the program, as well as the interplay among the teacher participants, the facilitators, and the program content and design.

Desimone (2009) constructed a core conceptual framework of teacher PD for the purpose of unifying the field of research and allowing improved analysis of the

effectiveness of PD programs. Three core aspects of PD demonstrated significant positive improvement in teacher knowledge, skills, and classroom practice: reinforcing content knowledge, active participation during training, especially with other teachers in the same discipline, and the duration of the program (Garet, Porter, Desimone, Birman, & Yoon, 2001). These core aspects appear often in scholarly research.

Desimone (2009) proposed a linear design to a unified conceptual framework which incorporated the author's empirical findings, as well as those of Borko and others. The author emphasized the great importance of content; that focusing on the subject matter to be taught to students increases teacher knowledge which naturally leads to improved pedagogy, which then manifests itself in improved student outcomes (Desimone, 2009). Although content knowledge was found to be most significant in many studies, the U.S. Department of Education found that most teachers experience fewer than 8 hours of content-focused training each year (Desimone, Smith, & Phillips, 2007). The MSP program required many more hours of training than this.

Methods of Measuring Effect on Improving Classroom Practice

In this review of literature, I found three recurring features of teachers' PD that enhance sustainability of improvement in teacher effectiveness: leadership support, feasible and structured initial design, and teacher agency and engagement (Dimmock & Yong Tan, 2013). Several scholarly papers discussed the complexity and interdependency of the transfer of information and practice from the trainer to the teacher, and then to the student, and the importance of the subjective human element in the process (Desimone, 2009; Whitworth & Chiu, 2015). Additional findings identified meaningful PD, effective

mentors, and cogent connections among training programs as supports needed by new teachers to lead their students to higher levels of accomplishment (King, 2014; Lavigne, 2014; Sarama et al., 2015; Wlodkowski, 2011).

Many districts may rely upon imperfect statistical tools to yield teacher ratings, the results of which are used to reward or punish teachers (Blank, 2013; DeBray, Parson, & Woodworth, 2000; Hanushek, 2011; Leigh, 2010; Mayer, 1998). Different statistical methods may be used to evaluate teacher performance as it influences student performance in the classroom. Culpepper (2014) provided highly technical statistical formulae and analyses to compare sets of data, but found instances where one method was more reliable, and other instances where the other method was more reliable, again exposing weakness in interpreting data related to teacher performance, a recurring problem for school administrators on the local level.

Teachers' Perceptions of Their Professional Development

Soine and Lumpe (2014) created an instrument to measure teachers' perceptions of their PD and were able to demonstrate construct validity when applied over a large sample of elementary teachers from five school districts in Washington State. Predictive validity was slight but significant, when corroborated by classroom observation scores, and indicated a positive correlation between training and classroom benefit. Garner (2011) performed an ethnography to examine the perceived changes in mathematics teachers' beliefs, behaviors, and values as a result of their PD, and found that participants in this study had a positive perception of the benefits of their PD.

Conclusions

In my review of scholarly literature, I found a consensus for the need to improve student learning in mathematics. Student mathematics achievement had persistently declined in APS as well as throughout the United States and in many developed countries around the world. This global problem is acutely felt locally, as APS students lack the requisite mathematics knowledge to access new job opportunities opening in their community. Administrators and other decision-makers struggled to turn the tide and improve student outcomes.

One prevailing method to achieve this goal was through more effective PD of teachers. Many researchers acknowledged that "PD is a complex process that is not yet well understood" (Brodie & Shalem, 2011, p. 419). I found a wealth of literature suggesting the need for more persistent content and pedagogical training for mathematics instructors, but a dearth of empirical study on the efficacy of this PD and its sustained benefit in improving teacher effectiveness.

MSP is a federally funded PD program funded by the National Science Foundation (NSF) whose intent is to improve STEM instruction. APS participated in this program and offered all secondary school mathematics instructors 3 years of monthly full-day PD to stem the tide of declining student achievement in mathematics and science courses. In my review of scholarly literature, I found analyses of successes and failures of similar programs shortly after cessation of training, but few authors collected and analyzed longitudinal empirical data regarding the sustained efficacy of their programs. Most authors called for further study and greater rigor.

In most of the studies examined in this review of literature, the authors viewed PD as strengthening teachers' content knowledge and expanding their repertoire of pedagogical techniques which would, in turn, improve their professional practice, ultimately resulting in improved student outcomes. Several studies emphasized the importance of active participation of teachers in their own PD, as well as fostering collaboration among these practitioners. I found no study whose author developed a clear causative link between PD and improved student outcomes, but several did indicate a contributory effect, at least in the short term, of PD of mathematics teachers.

A few studies reviewed were large meta-analyses, one of which aggregated data from 910 research studies specifically focused on the effectiveness of PD programs for mathematics teachers. Only a small fraction of these 910 studies yielded reliable empirical data suggesting a direct, positive causative link. Several studies provided disparate findings using similar sampling techniques, similar research questions, and similar methods of analysis. Many scholarly works cited confounding variables and biased samples as common causes for unclear findings. One example of biased sampling offered by an author suggested that if a training program were not compulsory, higher performing teachers would be more likely to take part in PD and weaker teachers might not bother, thusly the research sample would contain a predominance of teachers who would perform better in their classrooms whether they experienced the training or not.

Many international studies mirrored the concerns and results of school districts in the U.S., and specifically in APS. One outlier was Singapore, which maintained persistent excellence in student outcomes and competitiveness. More than one study

attributed the educational success of Singapore to cultural traditions, homogeneity, strong family support, and persistent PD. Other nations more like the United States in ethnic and economic diversity share the struggle to improve instruction in the hope of attaining higher student achievement and greater economic competitiveness.

Features of successful PD programs were often enumerated, and commonly listed variables were teachers' perceptions of student achievement, how well the teachers understood proposed innovations, degree of experience of the teacher, skill and pedagogy of the presenter, degree of participation and collaboration of attendees, and the length and frequency of the training program. Brief PD programs sometimes demonstrated short-term benefit, but rarely any sustained effect on classroom performance. More persistent training programs appeared to have longer-lasting benefit, but systematic longitudinal empirical study was rare, and assessment instruments often lacked rigorous measures of reliability and validity.

Expense of training programs and cost of classroom observation needed for proper assessment of sustainability were discussed in several papers and were presented in detail in a few lengthy governmental reports, which weighed the cost/benefit ratios of different programs. Financial benefits of successful training included teacher retention, and fewer repeat and remedial courses needed due to higher passing rates for students. Careful assessment of PD programs in their early stages before they are scaled-up and deployed statewide was highly recommended, because training is costly and finite resources are wasted on ineffective programs.

In conclusion, most scholarly papers indicated that PD was beneficial and cost-effective if well designed and properly executed by skilled trainers over several sessions. In addition, most researchers called for more study, more empirical data collection, and more longitudinal assessment. APS would benefit from the findings of an informative study of the sustainability of the MSP PD program. This study is designed to fill this gap in understanding by qualitative study of the perceptions of past APS participants of the MSP PD program.

Implications

This research project study resulted in findings that were used to develop a report to provide information that APS administrators need to develop effective PD programs with long-lasting benefits for their mathematics teachers. The implications of this report could lead to improving the MSP PD program, changing how it is implemented, or abandoning it. Because this narrative was based on an analysis of interview data collected from past participants of the MSP program, I anticipated a broad spectrum of responses, both positive and negative, based on the insights of the responding teachers. Qualitative analysis uncovered some themes of consensus among the interviewees about their perceptions of benefit or lack of benefit from their training over the past few years since the program ended.

The MSP program was conducted during a time of flux, as mathematics curricula in APS classes were being converted to the new Common Core standards, which included new textbooks, new conceptual approaches to the material, and new approaches to pedagogy. I intend to produce a deliverable product of this research that will indicate to

administrators and department heads the perceptions of their teachers who participated in the MSP program, regarding the value, applicability, longevity, and efficacy of their training, as well as their suggestions to improve the program. The implications of decision-makers having current qualitative data upon which to plan future PD could lead to better classroom pedagogy and greater retention of teachers.

Summary

APS, like many other urban school districts, was facing a growing problem; their graduates were unprepared to enter the new workforce which now demands technical skills and understanding. To compound the gap between declining student performance and greater competition for employment, APS was also introducing new Common Core standards which are significantly more rigorous than the previous curriculum. APS administrators engaged a renowned scholar to advise them, who stressed the need for persistent, high quality PD.

In response to the challenge to improve mathematics instruction, APS administrators collaborated with a local university, and with federal funding developed a 3-year PD program for its mathematics instructors under the auspices of the MSP. Participants in this program were carefully monitored, with annual pretests, posttests, and classroom observations (Roden, 2016). A careful study of student achievement results performed by a local university indicated an improvement immediately after the program ended, but this improvement was not sustained in the following years (Eisenhart et al., 2015). I found scholarly research studying sustainability of mathematics PD to be sparse.

The goal of this research was to query the recipients of the MSP PD, the teachers, and gain from them their insights into the successes and failures of this 3-year program. Of interest to this study is longevity of the benefits of this training. A large-scale enterprise such as the MSP program is difficult and expensive to undertake, and administrators need empirical qualitative data upon which to make efficient use of their finite resources (Archibald et al., 2011). The product of this research, a deliverable report to administrators, may provide them with actionable data upon which to improve the longevity of PD of their mathematics teachers.

The remaining sections of this research paper include details of the methodology used to collect, organize, and analyze qualitative data, leading to the findings included in the position paper prepared for APS administrators. Among these details are the criteria for selecting participants, research methods employed, and protections afforded to interviewees to guard their confidentiality and protect them from harm. Data organization using a spreadsheet, and procedures to assure the accuracy of data using the transcript verification method are explained.

The project resulting from the findings of this research is included as Appendix A. This position paper was prepared to assist APS administrators by providing suggestions for future PD based on the perceptions of their mathematics teachers who attended previous MSP training. The position paper includes background material explaining the problem, evidence from scholarly literature and research findings, and recommendations suggested by APS teachers to improve PD.

Section 2: The Methodology

The goal of this study was to examine the success of the MSP PD program from the perspective of its participants. I based the study on Patton's (2002, 2003) methodology of qualitative research, which is an examination "conducted systematically and empirically through careful data collection and thoughtful analysis" (Patton, 2002, p. 10). Specifically, I followed a heuristic approach to interviewing participants that allowed for flexibility in data collection leading to greater discovery. Careful analysis was required to arrive at comprehensive and compelling findings (Marshall & Rossman, 2014). Merriam and Tisdell (2015) indicated that the goal of heuristic qualitative data analysis is to reveal information that will cause the reader to think beyond the immediate factual finding in order to gain a broader understanding of the solution to a problem. In conducting this research study, I wanted to gain greater understanding of the sustained efficacy of the MSP PD program from the perspective of its teachers.

Qualitative research differs from quantitative research. The quantitative researcher, as the term implies, collects and analyzes numerical data, which allows for the development and statistical testing of hypotheses (Creswell, 2012). Qualitative researchers pose research questions to human subjects, which offers a broader palette of response (Creswell, 2012). Using this more open method of inquiry allows for "uncovering the meaning of a phenomenon" (Merriam & Tisdell, 2015, p. 5) because interviewees can offer information beyond simply answering questions from a researcher. Quantitative researchers generally follow the deductive scientific method. The researcher first proposes a general statement, the hypothesis, and then seeks to prove or disprove this

supposition through systematic observation and manipulation and control of variables (Lodico, Spaulding, & Voegtle, 2010). In contrast, qualitative researchers examine concepts rather than variables to induce an understanding of the studied phenomenon (Creswell, 2012; Lodico et al., 2010).

Whereas qualitative study induction can be quite open and broad, purposeful sampling methodology imposes limits or boundaries which allow meaningful focus on the subject of a scholarly study (Hancock & Algozzine, 2016; Merriam & Tisdell, 2015). The universal set of this study was all high school mathematics teachers in APS who attended the full MSP PD program. The purposeful sample was a collection of those teachers willing to share their professional experiences and observations.

This study differs from a program evaluation in that a program evaluation is based on an evaluation objective, "a clear description of a goal used by the evaluator to judge the worth or merit of a program" (Spaulding, 2014, p. 15). I chose the qualitative research method because the goal of this study was to collect and analyze the perceptions of participants regarding how they benefitted from the MSP PD program. Although study findings are strictly limited to the selected sample of participants, the findings are not bounded by preselected evaluation goals, but rather allow for induction of emergent themes (Kannenberg, 2014).

Conceptual Framework of Inquiry

The conceptual framework of inquiry for this study was Kleining and Witt's qualitative heuristic approach, which is based on systematic exploration and discovery (Kleining & Witt, 2000; Naber, 2015). This design, an extension of Moustakas' (1990)

work, is a form of qualitative study that allows for the immersion and insights of the researcher as an active participant in a qualitative study. Rennie (2012) indicated the lack of a unified qualitative body of research methods, but amalgamated all heuristic research as hermeneutical, where each small finding leads to an understanding of the whole, and the whole in return clarifies understanding of each part. As such, I intended to collect and analyze empirical qualitative data to seek points of consensus among mathematics teachers in suggesting improvement in their PD.

Perceptions of a Causal Relationship Between PD and Improved Classroom Practice

Qualitative research does not often lead to definitive findings of direct causative links because it explores the human condition, which is replete with confounding variables; however, careful empirical qualitative research can be used to develop and defend perceptions of causal inference, a weaker relationship that can accommodate the variability inherent in human research (Sobel, 1995). In my review of scholarly literature, I found an underlying assumption that PD of teachers would naturally lead to higher test scores for their students, but there was clearly no consensus among researchers of this causal inference or link (see (Copur-Gencturk, 2015; Dunn, Rabren, Taylor, & Dotson, 2012; Gersten et al., 2014). In this study I explored the perceptions of field practitioners, experienced teachers who attended the MSP program; a possible outcome was to potentially expose recurring themes in contradistinction to rigid direct causation. The group of interviewees was selected to provide a variety of professional experience to enhance “variation in perspectives and experiences to promote the emergence of themes” (H. M. Johnson, Warner, LaMantia, & Bowers, 2016, p. 2).

It might seem logical that there is a natural causative linkage between teacher training, teaching practice, and student outcomes, with effective teacher training leading to better teaching and better teaching leading to improved student outcomes. A few empirical studies have supported this causal association (McMeeking et al., 2012; Sarama et al., 2015), but many other scholarly sources do not measure the effect of PD upon teachers or the influence of improved teaching on student outcomes (Antoniou et al., 2015). In one meta-analysis of current rigorous studies, the authors contradicted a common assumption that PD program design that includes strong content focus, inquiry-based learning, and collaborative learning will lead to improved student achievement (H. Hill et al., 2013). This counterintuitive disconnect is a profoundly local problem, because most PD is established at the district or school level, has a relatively short duration, and proceeds with little or no evaluation (Carney et al., 2016; Flint, Zisook, & Fisher, 2011).

Lack of Measurement of Effectiveness and the Need for More Research

Some studies that I reviewed supported the causal association between PD and improved student outcomes. Blank and De Las Alas (2009) found that "teacher PD in mathematics does have significant positive effects on student achievement" (p. 28). Conversely, other researchers found that "there is little empirical evidence to support the relative impact of PD programs on teaching practice" (Derting et al., 2016, p. 1). Many other researchers measured neither the effect of PD on teacher practice nor the effect of improved teaching on student outcomes (Antoniou et al., 2015; Culpepper, 2014; Hill et al., 2013).

Researchers have encountered challenges in assessing the immediate effects and the long-term sustainability of improvement in teaching as a result of PD (Antoniou & Kyriakides, 2013). Hill et al. (2013) found that many scholarly studies lacked rigor, and as a result offered little knowledge of which program characteristics are the most effective. Other researchers made special note of this gap in research in the efficacy and sustainability of PD, and called for more definitive study (Culpepper, 2014; Foster et al., 2013). This study may help in closing this gap in research.

I intended to study the perceptions of participants in a recent PD program for mathematics teachers, the MSP program, from an empirical, qualitative perspective. Gathering first-hand data from participants is more informative than relying on proxy variables such as teachers' years of service, degrees attained, or courses completed (H. Hill et al., 2013; Schmidt & Hunter, 2014). More specifically, inducing causality from a proxy variable can easily lead to imperfect construct validity (Schmidt & Hunter, 2014). However, evaluating empirical data from experienced practitioners in mathematics instruction can allow for valid and reliable conclusions to be drawn and recommendations to be made to administrators (Banilower et al., 2007; Foster et al., 2013; H. Hill, Rowan, & Ball, 2005).

Participants

Qualitative study design allows the researcher to collect verbal data from a sample of participants and analyze their responses with the goal of gauging the sustained efficacy of their MSP training (see Creswell, 2012). I planned to collect and analyze qualitative data from firsthand accounts gathered from participants in MSP training, rather than

relying on more conventional analysis of proxy data. This collection and analysis of teacher perceptions of the long-term effectiveness of their MSP training provided needed information to APS administrators to guide them in designing effective programs to improve delivery of mathematics instruction to students.

Teachers who participated in this study must have attended the full MSP training program, they must have taught mathematics for at least 3 years after the program ended, and they must not have worked at the same school as me. At least 50 teachers satisfied these criteria, from whom I selected seven of those who volunteered to participate.

Sampling and Sample Size

Robinson (2014) provided an excellent guide to developing an appropriate qualitative participant sample based on four points: defining a sample universe, deciding on sample size, devising a sample strategy, and recruiting participants. I intended to recruit participants by emailing informative requests to all past participants in MSP training, and from the volunteers, select participants with varying backgrounds, such as years of teaching experience, academic accomplishment, and courses taught. The list of these past participants was available from the mathematics department of APS, with the approval of APS's Office of Shared Accountability. Robinson (2014) recommended a sample size of 3-16 participants for an idiographic study such as this one, which allowed for more intense analysis, greater defined identity and clarity of voice of individual participants. I interviewed seven participants for about 30-60 minutes each.

Procedures and Ethics

Researchers working with human subjects must adhere to legal and ethical requirements to protect participants from mental, physical, or emotional injury (Hancock & Algozzine, 2016). All standards of ethical protection were scrupulously observed in collecting data for this study. I received permission from APS to conduct interviews with teachers, pending approval from Walden University Institutional Review Board (IRB). I completed National Institutes of Health (NIH) training in research on human subjects, and approval to conduct my study was granted by Walden University IRB, approval #10-05-18-0377609.

In order to gain consent from APS to gather interview data from colleagues, I applied to the school system's Department of Accountability. I provided the Chief Information Officer with a copy of my potential proposal, a copy of my NIH certification, and detailed information about my study and the protections I would employ to protect my human subjects. According to NIH standards, all of my interviewees were considered autonomous and non-vulnerable, and all offered their written consent to participate.

Additional consideration was necessary when interviewing colleagues in order to protect their professional privacy and allow candid responses to questions about their classroom performance as a result of their MSP training. To ensure the highest standard of candid response to research questions, only participants from schools other than my home school were selected, teachers with whom I have no professional relationship other than learning together occasionally at city-wide PD sessions for high school mathematics instructors. These interviewees were assured of confidentiality regarding their

participation and anonymity in the report of findings by labelling them simply Teacher 1, Teacher 2, and so forth.

I established a protocol to protect human subjects during the gathering of data and its subsequent analysis. I solicited participants by APS e-mail and invited them to be interviewed for about one hour. Those teachers who expressed an interest in participating were provided an overview of the study and a document indicating research procedures and protections afforded participants, requiring their signature granting their informed consent. Interviews were conducted in a closed room or by phone to insure privacy and candid responses.

All records, to include transcripts, voice recordings, and any document identifying participants, are stored in a locking steel file cabinet in my office. Electronic records are password protected. Participant names and other identifiers, such as home schools where they currently teach, are not needed and are not recorded with data. As a result, all data is anonymous to anyone other than me.

Data Collection

Data for this study were collected through interviews with selected teachers following Kleining and Witt's (2000) systematic framework of inquiry. All teachers who attended the MSP training program were invited to participate, except for teachers working at the same school as me. From those teachers who accepted the invitation and responded with their formal consent to be interviewed, I selected teachers from differing schools and differing levels of experience. Interviews were conducted in private, at the convenience of the interviewee.

Interviews were audio-recorded using Audacity software and transcribed shortly after each interview. Phone interviews were conducted over a high-quality speaker phone and recorded in the same manner. Kleining's interview format provided structure to align data points among interviewees, but also allowed for unstructured discussion, to include additional, unanticipated data. These data were organized using the framework method of management and analysis of qualitative data which organizes a set of codes into categories focused on answering the research question (Gale, Heath, Cameron, Rashid, & Redwood, 2013).

Professional standards of data collection were carefully observed for the protection of participants' rights, confidentiality, informed consent, and protection from harm. All notes and transcripts were anonymized, with the only record of actual identities recorded on the emailed consent forms, which are stored in a locked file cabinet for 5 years, as required by Walden University.

Sampling

All previous MSP participants still teaching mathematics in APS were emailed an invitation to be interviewed, with the permission of APS. From those responding favorably, I selected a sample, intentionally avoiding those with whom I have had a close professional relationship to prevent any conflict of interest or the appearance of any influence on data collected. This purposeful sample of teachers who attended the full 3-year MSP program was interviewed individually for about 30-60 minutes each. Interviewing 7 teachers from different schools with different levels of experience allowed

a broad view, but still permitted in-depth interviewing and manageable data coding and analysis

Data Analysis

After I transcribed each interview, I listened to selected parts of each interview recording to enrich understanding of transcripts for greater accuracy and completeness. Interview data contained in the transcripts of the interviews was coded and then sorted into categories and organized using a spreadsheet. In order to enhance validity of these data, I employed the transcript review method, whereby a transcript of an interviewee's responses can be reviewed and validated or corrected by the originator of the data (Koelsch, 2013). I mailed to each participant a copy of my transcript of their interview and allowed them 7 days for their examination and comment. Mail was sent using APS inter-school mail, with no identification of the sender.

I followed Patton's (2002) triangulation method, "consistency of findings across methods and data sources" (p. 268), to find common themes among interviews. However, in the same scholarly paper, Patton indicated that, regarding qualitative interview data, "no straightforward tests can be applied for reliability and validity" (p. 276). Discrepant, conflicting views are also important information which will be included in data analysis (Cho & Lee, 2014). Conflicting statements from participants are included verbatim to provide more information and greater authenticity.

Interview Protocol Design

Roden (2016), the original evaluator of the MSP program in this study, did not conduct interviews with participants of the MSP program or perform any longitudinal

study. He recommended that I should review with interviewees some classroom goals and objectives taught in the MSP program and ask them if these specific practices were still in use 3 or more years after cessation of the program. I was concerned that this might skew my data if I offered this information at first, but I intended to prepare prompts if needed to gently refresh the memories of my interviewees. Using Roden's guidance and Desimone's (2011) conceptual framework, I divided my inquiry into the four research categories included in my overarching research question, value, applicability, longevity, and efficacy:

1. Regarding value, participants will be asked if they perceived that the benefit they accrued from their MSP training was worth their time away from the classroom and the financial expense of the program.
2. Regarding applicability, participants will be asked if their new learning was pertinent and significant to the curriculum they taught.
3. Regarding longevity, participants will be asked to determine whether the benefits of their MSP PD endured 3 or more years after the end of training.
4. Regarding efficacy, interviewees will be asked if they felt their training helped them improve their pedagogy and content knowledge.
5. Interviewees will be asked to share their recommendations to administrators, trainers, and funders to improve the initial training and its sustainability.

The complete interview protocol in is Appendix B.

Implications

My goal in this research was to collect and interpret data in the hope that a report of my findings might effect positive social change. This could be accomplished by assisting APS administrators in enhancing the training of their mathematics instructors, which in turn might lead to improved mathematics accomplishment by APS students. Closing the existing mathematics achievement gap may open employment and college opportunities to APS students which can allow them to escape poverty and lead more successful lives.

Qualitative research is exploratory in that data are collected without the goal of supporting or not supporting a predetermined hypothesis, but rather with the goal of understanding human opinions and experiences to induce possible directions of further study. Through this qualitative study I intended to probe a purposeful sample of experienced teachers to find informative suggestions to help administrators design better PD programs for mathematics teachers. As empirical data were collected, organized, and analyzed, I expected to uncover recurring themes that would lead to a useful project report that may provide needed evidence upon which administrators can make informed decisions to improve PD of their mathematics teachers.

Summary

APS, like many other urban public school systems, desires to improve the mathematics achievement of their students. The city is experiencing a rebirth of new construction including a billion-dollar solar panel factory, but their students lack the technical skills and mathematics background to fill many of these new positions. School

administrators attempted to improve student outcomes by providing their mathematics teachers with a 3-year, mandatory PD program under the auspices of the national MSP program.

A careful study performed by a local university found that student exam scores did indeed rise after their teachers completed the training regimen, but these gains were not sustained. The MSP program was also carefully monitored and evaluated, with annual pretesting and posttesting of the content knowledge of participants, and multiple classroom observations during the 3-year training period to evaluate implementation of improved pedagogy in the classroom. There was no follow-up study of the MSP PD program in APS after the training ended.

The goal of this study was to uncover and share with administrators the experiences and advice of its practitioners, the mathematics teachers who attended the PD sessions and then deployed this new content knowledge and improved pedagogy in their classrooms. I intended to select a purposeful sample of teachers who attended the full 3-year program and to solicit from them detailed responses to interview questions probing their perceptions of the efficacy and longevity of the benefits of their MSP training. I inquired how their pedagogy changed, how their knowledge and understanding of mathematics deepened, and most importantly, how they perceived their students benefited from the results of the MSP program.

After completing these interviews, the empirical findings were analyzed following a semi-structured systematic framework to deduce evidence to share with administrators in the form of a position paper with policy recommendations, based on the perceptions

and recommendations of past participants in the MSP PD program. Information in this report included teachers' perceptions of the value, applicability, longevity, and efficacy of their MSP training. These aggregated and anecdotal findings provide decision-makers with significant information upon which they can improve PD of their mathematics teachers.

Data Analysis Results

Qualitative data were collected by interviewing mathematics teachers who had participated in MSP PD program from 2010-2013, and who are still teaching in the APS system. Teachers were interviewed to gain their perspectives regarding this PD program, with special emphasis on its longevity, following a heuristic system of inquiry (Kleining & Witt, 2000). This heuristic framework allowed me to assist the participants when necessary to refresh their memory of their PD because they attended several years ago, and they sometimes needed clarification and affirmation that they were recalling the training from specifically the MSP program. Analysis of these data, combined with extensive review of scholarly literature, was the basis of the synthesis of my project, a position paper presenting information and suggestions to APS administrators. This collection and analysis of teacher perceptions of the long-term effectiveness of their MSP training provided needed information to APS administrators to guide them in designing effective programs to improve delivery of mathematics instruction to students.

Each participating teacher received a copy of the research question protocol more than a week in advance, and I questioned them in the order the questions were presented on the protocol. All interviews were audio recorded using Audacity software, which

provided accurate time-stamping to allow me to return and review statements easily if I needed clarification. Each participant was identified only as "Teacher 1" or "Teacher 2" on the audio recording to maintain confidentiality. Actual identities were recorded on a table held in a locked file cabinet, and on a password-protected file on my computer. I manually transcribed each interview which allowed me to carefully understand every word spoken and to include time-stamps in my work product to allow efficient review of the original audio recording if needed.

In order to reaffirm the accuracy of my transcripts, I mailed a printed copy to each participant for their careful review and approval, using APS inter-school mail. Some participants made minor clarifications, but none indicated any misunderstanding or misstatements in verification their transcripts. Transcripts were initialed and returned to me by inter-school mail using generic school envelopes, with no return address, to maintain confidentiality.

Participants

Using Patton's (2002) qualitative study framework and Kleining's (2000) method of heuristic inquiry, I interviewed a purposeful sample of teachers who attended the complete MSP training regimen and were still teaching in the APS district. The goal of these interviews was to collect qualitative data in the form of the perceptions of these teachers of the effectiveness of their PD and the longevity of their learning in their practice.

Teachers who participated in this study completed the full MSP training program and were teaching mathematics in APS at the time of data collection. In order to broaden

the spectrum of respondents to enhance my purposeful sampling, I diversified my sample by selecting interviewees from subgroups who were younger and older, male and female, and new teachers and veterans at the time they participated in the MSP program (see Palinkas et al., 2015). Two teachers had earned doctoral degrees at the time of their training, one subsequently was awarded National Board certification, and one teacher had just begun practice and had no previous exposure to the scientific calculators or other computer technologies used by APS.

All teachers were fully certified and licensed by the state, but some were primarily education students in college who added mathematics as a specialty to their degree, and some were mathematics majors who added education courses for the purpose of obtaining their teaching license.

Data Organization

Extensive verbal interviews generated large amounts of qualitative data. I selected the framework technique, based on Microsoft Excel spreadsheet technology, which is commonly used in the field of health care. I selected this method because I was trained in Microsoft Office previously and was already proficient in Microsoft Excel. This technique provided a "simple and rigorous method to manage and display qualitative data, using widely available computer software, which removes the need to acquire and learn more complicated, dedicated software" (Swallow, Newton, & Van Lottum, 2003, p. 610).

Following my interview question protocol, I established basic headings into which to subdivide statements recorded from interviewees. As qualitative data grew, and

I revisited my findings, I added subcategories to refine my organization and accommodate unexpected perceptions. Although the spreadsheet grew to many pages, making a printed copy untenable, it was easily visible and searchable on a double-monitor display.

As themes emerged on my second and third review of the data, I inserted key search words into notable statements to make them easier to recall when needed. The addition of this encoding allowed for three-dimensional organization: by general topic, by participant, and by emergent theme. On my fourth review of the data and a careful rereading of the literature, I was able to interleave scholarly references with my newly collected data to develop a rich blend of local teacher perceptions and general scholarly observations.

Accuracy and Reliability of Findings

All data collection procedures required by the National Institutes of Health for research with human subjects and by Walden University's IRB were carefully followed. These practices protect the interview participant from harm, and also protect the qualitative data from adulteration. All interview statements were audio-recorded, with the identity of the participant held confidential, and all written transcripts have been verified by each interviewee for accuracy.

Research Findings

The overarching research question of this study is teachers' perceptions of the sustainability of their MSP PD, which ended 5 years before these data were collected. Interviewees' verbal responses to my interview protocol elicited a broad spectrum of

perceptions, with some teachers reporting that they gained much useful information and improved their pedagogy, while others felt that much of their time was wasted, and their students suffered from their absence from their classrooms on a recurring basis over three years. Some teachers expressed contempt for colleagues who would attend (attendance was mandatory) and not participate, because they felt the presentations were valuable and some teachers were abusing the opportunity to improve their craft.

The diversity of sampling led to different perspectives on the two thrusts of the MSP training, content knowledge and pedagogy. Some of the math and science majors found the content training below their level but were very engaged by the hands-on techniques and new communication technologies presented that enhanced their pedagogy. Teachers who were not primarily mathematics majors indicated that they benefited greatly from 3 years of review of Algebra 1, Geometry, and Algebra 2, led by a college professor. The variety of responses provided distinct, granular detail to my findings, but these somewhat disparate responses also led to several emergent themes. This commonality evolving from dissimilar data gave credence and salience to my findings.

Research Question 1: Value

How do teachers who participated in the MSP PD program perceive the value of the program as related to their personal effort, time away from class, preparation of work for their substitute teacher, travel to another location, and cost to the school?

The MSP PD program provided regular intensive training, approximately one full day per month, over three years, for all high school mathematics teachers, and their

special education support staff members as well. A substitute teacher was provided for each teacher attending the training regimen. Attendance was scheduled and mandatory.

Preparing a lesson to be executed by a substitute teacher requires effort and careful forethought, and many substitute teachers are not mathematics teachers, which limits the lessons they can execute in the teacher's absence. The regular teacher still had to grade all of the assignments completed during the absence, and in addition, the teacher had to travel to a different location for the day-long training. RQ1 was intended to ascertain if the interviewee perceived that this extra effort, the disruption of daily classroom routine, and the extra travel, was worth it.

In addition, all APS teachers are taxpayers. The MSP program was an additional expense to the APS budget, with teacher payroll, substitute teacher payroll, and the cost of the actual program and its staffing. RQ1 inquired if teachers felt their tax dollars were well spent.

The general response of teachers was split between those who felt they received great value, which was well worth the effort and expense, such as T2, who stated "as far at the effort in preparing for a sub, I think that's really negligible if you have decent lesson plans…and worth the inconvenience of arranging for a sub and travelling to another school", and those who felt their time was wasted, such as "that time would have been better spent with my students" (T4). There were several expenses involved in attending these training sessions, but most teachers identified the midweek interruption of their weekly lesson, and its incumbent effort in preparing a lesson to be administered by a

substitute teacher, as major disincentives. T4 stated that "I think there was some value, but not to the extent for the time that we sacrificed out of the classroom."

Some teachers felt very strongly that the improvement in their content knowledge and insights gained in their pedagogy far outweighed the inconvenience and extra work needed to attend the training sessions. Qualitative data collected included statements such as "value was so much more than the work involved to attend" (T1), "I definitely think it was worth it…I learned a lot, stuff that I could use in the classroom right away" (T7), and "I thought that the MSP was definitely worth it,…I find PD always to be useful. I learn a tremendous amount from it" (T2).

Some teachers were more equivocal in their response, such as "40-50% of what we gained was worth the time invested, but the remaining 50-60% wasn't worth the time out of the classroom" (T4), and "I hate missing class, but any opportunity to reflect on our craft even if it's bad PD which (the instructor) would never give bad PD, she's a class act, but even from bad PD you still get a chance to reflect and that has value" (T5). And some participants were clearly negative in their response. One teacher felt that the material presented had already been mastered "It wasn't worth it to me, I had much of the material before in college, I was exposed to a lot of that in graduate school. It wasn't very informative for me" (T5). Another identified the great disruption in the classroom as a problem, stating "I never like to be out of my classroom unless it is absolutely necessary, so...unless it is something completely above and beyond, something impactful or so immediately implementable in the classroom, I don't like to disrupt the continuity of the week" (T6).

Most interviewees had little comment on the financial cost of the program, but some viewed the MSP program as a good value, "Now I can say I think money is wasted on some training…and 10 years later I am still NOT saying that about the MSP grant" (T1). Some clearly felt otherwise, "A good return on your investment? No. Maybe 10% return on the value of my absence" (T6).

Research Question 2: Applicability

How do teachers who participated in the MSP PD describe to what extent and in what fashion their new learning was related, pertinent, and significant to the curriculum they teach?

Common Core State Standards (CCSS) were being introduced nationwide at the time of the MSP training, and the actual change in curriculum and teaching materials would be enacted shortly thereafter. Did the MSP training prepare teachers adequately to integrate the new standards and teaching materials? Were teachers better prepared for the transition as a result of this PD? Did the content knowledge and pedagogy training result in improve student outcomes as the CCSS was introduced?

This RQ received the most attention from participants because the MSP training was multifaceted, addressing mathematical content knowledge, new technology, pedagogy, and the introduction of new CCSS standards. The introduction of the new Texas Instruments Nspire calculators with the Navigator communication capability was a major component over the 3 years of training. Many afternoons were spent learning the many new features that were a major departure from previous calculators used in the classroom.

This new technology allowed all students' calculators and the teacher's calculator to be networked and projected onto a screen or an interactive white board (IWB). The teacher could demonstrate to the class or select a student to lead the class, fully visible on the screen in front of the whole group. Training teachers in mastering and then integrating this new tool became "crucial factor in the adoption of technology in the mathematics classroom, which concerns the perceptions, attitudes, PD experiences and support networks for teachers to enable them to integrate its use into their regular practice" (Clark-Wilson, 2010, p. 749).

One salient theme that emerged from my data collection was teacher engagement in training and implementation of the Nspire calculator system. Almost all teachers mentioned their lessons on the calculator favorably and that they were able to use it in their classroom (not every teacher received a classroom set of new calculators right away) and that this aspect of the MSP program is still in use. T7, an experienced teacher with advanced degrees, expressed the value of the new calculator training thusly: "Our students being able to graph functions and compare relationships on the calculator…being able to display their knowledge using the Navigator…it's something the kids could use immediately, it made their learning a lot easier." T1, a new teacher at the time of the MSP training reiterated "The thing I remember the most was the calculators, they are an important part of being a math teacher. The technology changes but a lot of what we did with the calculators was essential."

Not every teacher felt strongly about the benefits of the calculator training. T4 stated that "I invested hours and hours and hours to understand, but my working

knowledge could have been much better the first two years I used them (the Nspire calculators) had the training been more effective." T3 reported benefitting from the calculator training, but not to the extent of others, and the school has not yet adopted the new calculators. T6 took a broader view of the topic of technology in the classroom training, opining that "Technology is great, calculators are great, but it doesn't erase the underlying variables that contribute to education…it doesn't erase poverty, it doesn't erase absenteeism, or any of those major issues that teachers always have to battle with."

Calculators are a concrete technological tool, whereas curriculum is less tangible and more variable. Teachers often teach different mathematics courses each year, and cities and states alter their curricula and textbook resources, especially with CCSS being introduced shortly after the MSP training. Questioning a group of teachers regarding the applicability of training to their classroom practice provided a broader spectrum of response. Some teachers indicated that the quality of the presenter made a significant difference in how well the material was assimilated by the teacher and applied to their classroom practice. Many teachers regarded having college professors teach much of the content knowledge portion provided training that was superior to many other PD lessons outside of the MSP program.

Teachers offered many disparate comments regarding the applicability of their content knowledge and pedagogy lessons, with no clear pattern or singular emergent theme. Some teachers stated that they were teaching upper-level courses and instruction in basic algebra was of little use in their classroom, and conversely, several basic algebra teachers found lessons in geometry and advanced algebra to be of little use. T3 recounted

that the principal asked what had been learned the previous day in the MSP program. T3's response was:

> "I would tell him we spent the first half of the day folding up a newspaper…and we needed to find the volume and how many pages were in the paper, it seemed like more tricks than anything they would see on the exam. I thought what they were trying to do in MSP was to make your class more enjoyable for your students. I don't think they realized from the teachers' perspective that we didn't have a lot of time for that stuff."

T6 provided a similar response, and did not experience a strong relationship between training and classroom application: "A lot of times it was hit or miss, a lot of times it did not match what I was teaching…a lot of the PD we get is general, not directly tied to what we are teaching…I don't even remember what we learned."

Most teachers did report positive perceptions of the general applicability of their MSP training. "I think it positively affected my students; I got a tremendous amount out of it. Using the pictorials rather than the numerical values, and then switching to the numerical values…I think that was really important" (T2). T5 reported that the main college presenter "always passed on some eye-opening and mind-opening information."

One specific area of negative agreement among participants was the applicability of the MSP training to the new CCSS, and more specifically to the EngageNY materials that were replacing all traditional textbooks and previous methods (T5, T6). Most states within the United States adopted a common standards-based curriculum based on three strategies: "the movement to common-standards; advances in technology-based

instructional resources; and the pressure of accountability measured by end-of-year assessments" (Reys, 2013, p. 35). Many teachers found fault in the poor quality of the new EngageNY materials and the lack of MSP training on how to compensate for their inadequacy.

T3 indicated that "I think the common core took all the creativity away, depending on where you work, if you have to follow strictly, you don't have the time to develop or implement the things we learned in MSP." T4 felt that the new CCSS materials were not yet available to our instructors and they were "informing us that the changes were coming and that it was our job to find out about them and to incorporate them into our classroom." T5 went into greater retrospective detail in sharing that "The last couple years I tried going back into the EngageNY modules to find some value in it so all the value I found was from me literally digging through the pages and finding the activities that work for me that I could even fathom putting my kids through." No teacher expressed any positive perception of being adequately prepared to use EngageNY materials.

Research Question 3: Longevity

How do teachers who participated in the MSP PD describe to what extent the benefits of training endured, and to what degree?

The MSP PD program for APS high school math teachers spanned the years 2010-2013. Careful pretesting, posttesting, and classroom visits were executed by an outside agency as required by the U.S. Department of Education (2017) which funded the program. No longitudinal or follow-up study has yet been conducted to assess the long-

term benefits of the training as perceived by the practitioners, the classroom math teachers who attended the PD program (Roden, 2016). Questions of interest were to what extent did teachers feel they benefited immediately, and to what extent was the benefit sustained in their professional practice. Were there any specific lessons that they developed as part of the MSP project that they still use today?

Some teachers had clear memories of individual lessons as part of MSP training, but most had little or no specific recollection, without prompting. Several interviewees indicated that over the past several years their mathematics department had provided many different PD opportunities, although none were comparable in the frequency, intensity, and 3-year duration as the MSP program. In spite of the magnitude of the MSP program, several teachers struggled to recall specific lessons included in the PD program. Some teachers, upon reflection, realized that lessons they were using currently in their classrooms originated from their MSP training.

T1 recalled "I still remember one of those handouts…a scavenger hunt on how to find different buttons on the calculator, how to find different options. And that goes back to MSP training". This refers to a lesson T1 still uses in classes to familiarize students with the calculator. T5 indicated "I'm having a hard time differentiating between the MSP program and the many other PD sessions we've had in the past…there have been a lot of different ones, and each one I feel had value." But then he paused and recognized that an entire trigonometry unit he had modified and shared with another teacher originated from his MSP training. The teacher with whom he shared his MSP lesson

shared it with others and has that on the wall in the hallway, "so not only did that affect me but that's also affecting other people …the next generation type thing" (T5).

Several teachers had faint memories of their MSP training, such as T3, "I have a hard time remembering some of our exercises in the MSP. I remember having a hard time with the white board and having to learn all the technology with the new calculators." T4 shared a sentiment expressed by others, "I'm having difficulty remembering specific examples, only because it was several years ago. Oftimes from training like this I incorporate pieces of training that are valuable, and I forget the rest." T6 stated more strongly that very little was remembered because it was not applicable to his urban students. In a similar vein, T7 indicated forgetting much of the MSP training over time because "There are a lot of things that I did not use right away because I did not teach that course or grade level for a couple of years and had since forgotten it."

Research Question 4: Efficacy

What strategies do teachers who participated in the MSP PD program describe as improving their content knowledge and pedagogy?

I wanted to know to what extent did the MSP training change the teacher. Some participants were new teachers, some teachers were education majors who studied some mathematics, some teachers were mathematics majors who decided on education as a career later in their education. Was the 3-year MSP program transformative in how teachers viewed their careers, how they viewed mathematics, how they viewed their students?

The MSP program was manifold in that it focused on reinforcing content knowledge, demonstrated a variety of pedagogical techniques, introduced new technologies, especially the Texas Instruments Nspire calculator, and introduced the impending CCSS transformation. Interviewees were queried over this broad palette of potential growth in their classroom effectiveness and asked to provide examples of successes and failures in classroom application and student outcomes.

T7 felt very strongly that the training was efficacious in that what was learned about new technologies, and especially the new calculator, T7 was able to share with other teachers, and they also then benefited from the MSP training. T5 found efficacy in the method of presentation, that "In our class we learned more through reflection. I imagine they gave us free time at our tables to reflect, to make a poster, put something on a Post-it note…some kind of reflection. If they did that, they built my pedagogical muscle."

One teacher who had mostly negative regard for the MSP training did incorporate an important emphasis of the MSP program into general pedagogy "I do remember one teacher who presented an example of how he had turned his classroom into learning centers and had the same material presented in a variety of different modes and he really explained how and why he constructed it and how it was used. He showed a videotape, that was a very useful lesson" (T4). This same teacher was inspired by this learning center concept, even though it has not yet been incorporated into the classroom.

In addition to strategies learned to improve content knowledge and pedagogy, efficacy of this training regimen included the extent to which participants changed how

they view their jobs as math teachers. T5 stated frankly that "There were some teachers who were just complaining the whole time, but it opened my eyes that it got me from where I was to where I am today." He also added later in the interview that "I imagine you would have to attribute some of the growth to the three years of MSP because we learned a lot inside the classroom, but we also learned a lot of pedagogy."

T2 did not think MSP changed the view of the job, but later reflected upon the enthusiasm shared by the cohort and "having a high for a week or two after one of those trainings. Of just being really happy to be in the classroom, of being excited about the content, showing my students 'oh I just learned the neatest thing yesterday, look what we can do now!'" T1 was a new teacher at the time of MSP and felt more accomplished as a teacher after having a regular time and place to ask questions of experts. T1 also felt that reviewing the content of each math course, Algebra 1, Geometry, and Algebra 2, was very reassuring, because as a new teacher "you find out what you will be teaching the first day of school most of the time, and you have no time to prepare."

Patterns, Relationships, and Themes

Collaboration

T1, the newest teacher in this sample to participate in MSP found the collegiality from more experienced teachers very supportive and indicated that MSP was "a place where you could go with questions and concerns…you never felt stupid." This theme was repeated by T5 who recalled learning much from sharing with other teachers when the group broke into collaborative mini sessions. In these smaller work groups, T5 found

"free time at our tables to reflect" and an opportunity to prepare materials to use in the classroom based on the collective suggestions of the cohort.

Calculators

An important content knowledge element of MSP was the introduction of the new Nspire calculators, which were a radical departure from all previous calculator systems APS teachers had been using. T7 felt very strongly that the MSP training in new technologies was more than just transformative to pedagogy; the training allowed the return to the building to train other teachers, thus magnifying the benefits of the MSP training. T1 identified the calculator training as the most important element and the longest lasting benefit of the MSP training.

T6, who felt only a 10% return on the investment of effort in this PD enterprise, found his new knowledge in using this mathematical tool to be immediately useful. T4 coupled the new technology of the Nspire with other computer-based techniques as a very valuable improvement in pedagogy. T3, who like T6 found little value in the MSP experience, did specifically mention benefitting from the calculator training.

Substitute Teachers

Every teacher acknowledged that in order to attend full-day sessions during regular school hours, they needed to be replaced by a substitute teacher. Some teachers found this to be a necessary effort which led to long-term benefit. Others found the work in preparing a lesson for a substitute teacher who was not a mathematics teacher, having to correct all the work done in their absence, and having their weekly routine broken on a monthly basis, to be not worth what they gained in their PD.

T1 and T7 felt very strongly that the value of their training was well worth the effort; that they learned a "tremendous amount" and they could "use it in the classroom right away." T3, T4, and T6 felt the multiple disruptions significantly harmed their students and imposed additional work upon the teachers. T6 lamented that there were benefits from MSP, especially learning the new technologies, but suggested that "there could have been other ways that we could have received that training." T1 shared the insight of not yet being married that at the time of the MSP training and having time to perform the extra lesson planning required to accommodate a substitute teacher. At the time of the interview several years later, T1 remarked that "now I wouldn't want to be pulled out of my classroom once every other month, I have young children, I have to take off occasionally because they are sick…I try really hard not to be out of my classroom."

Common Core State Standards

At the end of each interview I asked each participant to speak freely to offer suggestions to administrators about improving PD. The most prominent pattern of discussion was the impending change in curriculum and pedagogy to integrate CCSS. The classroom materials were not yet completed at the time of the MSP training, but the general framework and neology were ready for dissemination.

The attitudes among respondents regarding CCSS and the curricular materials imposed upon classroom instruction shortly after MSP training were uniform and consistently negative. T6 stated that "The first thing we need to do as a city, as a state, is get rid of these common core standards…because it's not working." T3 felt the improvement in pedagogy that resulted from MSP training was wasted because "CCSS

took away all of the creativity in the classroom." After MSP training but before CCSS lessons were introduced to APS classrooms, T5 was selected to attend a seminar led by one of the creators of the new CCSS curriculum. T5 regretted that "I did not walk away with anything that I used in my classroom." T6 noted with irony being glad the CCSS materials were not yet ready during MSP training because "this was before anybody realized what garbage it would end up being…basically useless in my professional and personal opinion."

Some teachers were more moderate in their opinion of CCSS. T4 found value in the new conceptually based materials and the module framework but decried that fact that when the procedural materials did become available, there was no PD from the school district to support the mathematics teachers, stating "that it was our job to find out about them and to incorporate them into our classroom." T5 maintained this theme that there was some value in the new curriculum, but it could only be uncovered with great effort.

Summary

The overarching question of this study was longevity, to what extent and to what degree did teachers perceive their MSP training endured. A common occurrence during data collection was the inability of the interviewees to recall much of their MSP experience in general, and even less regarding specific lessons still in use in the classroom. The framework of inquiry selected for this qualitative research allowed the interviewer to gently lead the participant bringing to life these stored experiences, releasing a wealth of data.

Some teachers had vivid recollections connecting some of their favorite current classroom lessons directly to their MSP training and its incumbent collaboration among colleagues. Others felt unsure whether they were recalling experiences from their MSP training, or that of other PD sessions. Over subsequent years, teachers received occasional PD sessions on calculator techniques and frequent sessions on CCSS lessons as they were introduced in stages. Many teachers commented that these subsequent lessons, most often presented by administrators or fellow teachers, were less compelling than their MSP training.

APS provided its mathematics teachers with 3 years of PD under the auspices of the MSP with the immediate goal of improving classroom instruction leading to the ultimate goal of improving student achievement. During the years 2010-2013, teachers were removed from their classrooms about once per month for the purpose of attending full-day training sessions led by college professors and fellow teachers trained as mathematics coaches. The current research was designed to collect the perceptions of a sample of participants in the 3-year MSP program using scholarly qualitative research procedures, and to analyze and summarize these data. These findings were subsequently organized into a report to present to APS administrators to provide information upon which to improve future PD of mathematics instructors.

Participants in this study generally found value in their MSP training, although some questioned whether the benefits outweighed the expense of disrupting their classroom routine. Most teachers enumerated the drawbacks in leaving their classroom for a full day, about once per month, over 3 years. They needed to provide special lessons

that could be administered by a substitute teacher who would most likely not be a certified mathematics teacher. These lessons would have to be corrected and graded by the participants upon their return to their classroom the next day. Their daily classroom routine was interrupted, weakening the continuity of instruction.

Interviewees did not concur on their cost/benefit ratio analyses comparing the expense of leaving their classroom to perceived improvement in their craft. A few reported great value and minimal disruption, and some suggested that the benefits outweighed the deficits, but were not sure if the cumulative effect of repeated absences warranted the gain in student achievement arising from the new information and technology they brought back to their classroom. Some teachers clearly stated that the harm to their students overwhelmed whatever gains may have accrued to their academic performance as a result of teacher training.

Several interviewees identified having a college professor provide much of the content knowledge and pedagogy instruction as a notable differentiating factor, elevating this PD program over most others. These college professors presented mathematics content knowledge tied directly to the secondary school curriculum and offered additional insights and higher-level concepts to enrich the conceptual basis of the material and open avenues of differentiation for higher and lower performing students. All participants in this study found favor in this level of presentation, although those teachers who were mathematics majors in college generally stated that they benefitted by the insights more than the actual content.

Empirical evidence from data collected later in each interview affirmed the perceptions of the participants that college-level presentation was still efficacious after several years. By the end of each interview, almost all participants were able to identify at least one significant lesson they learned during their MSP training that they were still using in their classroom. This longevity was magnified by two interviewees who detailed how new knowledge they gained from MSP was shared with other teachers to improve their classroom performance as well. Having reflected upon the endurance of what they had gained from MSP, two teachers expressed contempt for other attendees who did not pay attention during the MSP sessions because these "slackers" missed important information that could have helped their students and colleagues.

APS schools adopted CCSS shortly after MSP training ended. This new curriculum was not yet available at the time of training, but some advance materials were available and were introduced during the last several PD sessions. Teachers were questioned about the applicability of their MSP training to the new pedagogical approach of CCSS. Three themes of MSP training emerged in the perceptions of participants as aiding the transition to the new curriculum: introduction of new technology, specifically the Nspire calculator, pedagogy that encourages students to develop multiple approaches to problem solving, and reinforcement of teachers' content knowledge.

Training on the new calculator system was led by two experienced mathematics coaches who were specially trained by the manufacturer, Texas Instruments. Almost every participant indicated that they received benefit from this training. Some teachers were excited and could not wait to share with their students the new techniques they had

just learned. Other teachers felt frustrated that their school had not yet received their classroom set of the new calculators and felt their training was somewhat wasted. One teacher lamented that new technologies may aid the student somewhat, but not enough to overcome the academic and socioeconomic deficits that burdened their students.

The morning sessions were led by college professors who often presented a mathematics problem, then challenged teachers working in groups to offer multiple approaches to solving these problems. Some teachers reported that they found little use in these exercises, that this approach did not directly address the issues they were facing in their classrooms. Others found these training exercises to be invigorating, allowing them to forge new avenues of discovery to open to their students, and to share with other teachers. Most participants in this study, after reviewing their 3 years of training during their interviews, found some benefit from these pedagogy exercises, and identified specific approaches that they adopted in their pedagogy as a result of their MSP training.

Teachers' perceptions regarding applying this these new strategies to the new CCSS curriculum was disjunct, primarily because of the EngageNY teaching materials that accompanied the new CCSS curriculum, rather than the curriculum itself. Some teachers found their new pedagogical approaches helped their students wend their way through these new lessons that provided less direct support and required more thought-provoking answers. Most teachers found the new lessons to be unusable, especially in an urban classroom, to the extent that they expressed that no pedagogy could overcome materials so devoid of content to help struggling students.

Recommendations

Policy recommendations that emerged from the perceptions of APS mathematics teachers regarding their MSP training were synthesized from four subsets of data based on research questions. Regarding value, interviewees generally agreed that the MSP program provided greater value than most other PD sessions in return for the teachers' effort and APS funding. Regarding applicability, many teachers felt ill-prepared for the introduction of CCSS, which began shortly after MSP ended, a feeling which was shared by many urban teachers, "only 50% of teachers working with low socioeconomic status students felt very or fairly prepared to teach the CCSS" (Davis, McDuffie, Choppin, & Drake, 2017). The third research question, sustainability, is the key issue of this research paper.

The broad variety of responses from interviewees, and the way some teachers changed their perceptions within their own interview, is also evident among the scholarly resources that I analyzed in preparing this study. Many scholarly authors indicated the need for more quantitative data to assess sustainability (Century et al., 2012; Cochran-Smith et al., 2013; Furlong et al., 2013; Gansle et al., 2012; Sarama et al., 2015). Among those authors expressing a finding on sustainability, a few found positive results such as Capraro et al. (2016), some negative, like Aladjem et al. (2010), and most with unclear findings, such as Hairon & Dimmock (2012), and Sarama et al. (2015).

The last research question examined efficacy, the improvement teachers perceived in the content knowledge and improvement in pedagogy as result of their MSP training. All teachers found some benefit and found significant, long-lasting improvement in their

classroom performance. In the body of literature that I analyzed, almost all papers found some immediate improvement in efficacy of teachers from PD, but most did not collect longitudinal data to substantiate the sustainability of this improvement.

The findings from my analysis and synthesis of empirical qualitative data led directly to the recommendations included in the deliverable artifact, the position paper with recommendations, which is the project of this research study. The first recommendation was that APS should continue future PD programs in the style of MSP. Teachers perceived the most important element of MSP was having college professors present the material, rather than fellow teachers.

The second recommendation to APS administrators was not derived from the four original research questions, but rather was the outcome of the fifth question which encouraged teachers participating in the study to offer any suggestions to administrators. Teachers were asked their general recommendations to APS administration to allow them to teach better and allow their students to achieve more. Every teacher recommended ceasing the use of EngageNY materials for teaching CCSS mathematics.

Limitations

Data were collected from participating teachers several years after the end of the MSP training. As a result of this delay, some teachers found it difficult recalling specifically what lessons were presented over the 3-year training period during MSP, and often paused to make sure they were not remembering experiences from a different PD session. Because this study is based on Kleining's qualitative heuristic approach, within the research framework I could lightly direct and remind the interviewees of which topics

were covered in MSP and which were not (Kleining & Witt, 2000; Moustakas, 1990; Naber, 2015). A little prodding was needed by many interviewees to recall many important perceptions, "I'm having a hard time differentiating between the MSP program and the many other PD sessions we've had in the past…" (T5).

Limitations regarding the success of the policy recommendations include the time and financial restrictions imposed upon administrators. One important restriction shared by most school districts is "the provision of time… schools not only need direct fiscal support but also guidance on how to analyze, advocate, and protect these investments in human capital" (Archibald et al., 2011, p. 16). In spite of the time and financial limitation, many administrators, view PD as a wise investment, "professional development represents a substantial investment of time on the part of the teacher and a significant financial investment on the part of the school or educational authority that funds it" (Hilton et al., 2015, p. 104). My project addressed improving the quality of PD with limited additional expense.

Section 3: The Project

Introduction

The product of this research project is a position paper to be presented to administrators of APS informing them of the perceptions of their mathematics teachers regarding their 3-year PD program under the auspices of the MSP. I analyzed qualitative data collected from teachers at the school and organized results to inform administrators of the benefits and drawbacks of this program from the perspective of its participants. Interviewees offered compelling suggestions to improve future PD of mathematics teachers, as well as additional unsolicited suggestions to improve the delivery of mathematics instruction in APS classrooms.

The goal of the project was to share findings with APS administrators which were synthesized from qualitative empirical data collected from their mathematics teachers regarding their previous MSP PD program. I selected and distilled the recommendations from transcripts that were verified in writing by each interviewee after each interview, lending credibility to their collected suggestions. I hope that these recommendations will serve as a guide for APS administrators in planning more effective PD in the future, leading to improved teaching, higher student achievement, and greater teacher retention.

Rationale

Position papers provide concise, directed arguments to identify a problem and offer solutions based on credible evidence (Hyland, 2018; Myers, 2019; Simon Fraser University, n.d.). The evidence in this study is the empirical qualitative data collected from past participants in the MSP PD program garnered from a series of interviews. I

used direct quotations from participants to affirm the credibility of the position paper's arguments and suggestions for improvements.

The process of writing a position paper can be characterized as a logical progression from proposing an idea to collecting data to support the proposal and then composing a convincing narrative furthering the proposal based on the data (Badger & White, 2000). The goal of my research was to gather and analyze the perceptions of mathematics teachers of a previous PD program, MSP, and then present my findings to APS administrators to guide them in providing more effective PD with longer term benefits. The best mode of expression and presentation of my synthesis and analysis was a position paper with recommendations (Hyland, 2014). As the collector and interpreter of data, I was the conduit through which experienced teachers could offer their perceptions and suggestions to administrators who select and fund PD sessions for mathematics teachers.

The use of a position paper allowed me to lay out the premise that efficacious PD could lead to improved student outcomes, that teachers felt the MSP program was superior to most others, and that future math PD should include some of the features of the MSP program. This framework gave orderly space to present background information from scholarly sources, condense data from teachers, and synthesize findings from empirical qualitative data (see Rothstein et al., 2016; Trueb, 2013). Finally, in the recommendation section, I highlighted the two salient points, that future PD should emulate MSP and teachers feel that use of EngageNY educational materials should be discontinued in APS secondary schools.

Review of the Literature

The project of this research study is a policy recommendation to school administrators detailing teachers' suggestions for improvement in quality and longevity of their PD, based on their experiences with the MSP PD program in which they participated. I based these recommendations on qualitative data collected from interviews with teachers, which was coded, sorted, and analyzed to identify recurring themes as well as unique observations. These recommendations, supported by empirical data from APS faculty members, form my project, the position paper with recommendations found in Appendix A.

Choice of Position Paper with Recommendations as the Genre

The recipients of my scholarly work are policy makers, not academicians. These policy makers, APS administrators, are entrusted by taxpayers to select the most efficacious and sustainable forms of PD for their teachers. They have many constraints to balance, such as union contract requirements, state and federal requirements, and finite financial resources, as they search for the best way to train their teachers (Dennison, 2018; Foster et al., 2013; Hansen-Thomas, Grosso Richins, Kakkar, & Okeyo, 2016; Pruitt & Bowers, 2014; Woo, 2016). Recommendations from their professional faculty may aid administrators in more effective planning and funding.

I concluded that the ideal genre to provide essential information is a position paper with recommendations (Hyland, 2014; Warren, 2018). The format of this genre is direct and expository, building the base by identifying the problem, then expanding this base with a review of related scholarly literature, and pulling it back together with

empirical, local findings from APS teachers. The findings are ultimately condensed into a limited number of concise recommendations substantiated by the previous exposition of research (Xavier University, 2019). This direct approach of presenting essential information in condensed form, supporting concise, actionable suggestions, is the essence of my project.

Argument and implied or explicit counterargument are essential elements of a position paper, where data are used to buttress one's argument to a convincing conclusion (Coirier & Golder, 1993; Felton & Herko, 2004; Olsen, VanDerHeide, Goff, & Dunn, 2018; Warren, 2018). My position paper includes two main arguments, that MSP style PD is preferred by APS teachers over what is currently being offered and that EngageNY curricular materials are regarded as inferior to what was used in the past, in the opinion of APS teachers. I included empirical qualitative data that I collected and analyzed in the position paper to support the main premises of the paper. In addition, I sometimes offered counterarguments included in reflections collected from participating teachers.

Myers (2019) offered a framework for a balanced position paper that gains strength by defending the author's premise by relating it to other positions. After articulating a clear claim, an author needs to argue based on reason and evidence, which in my case was data gained from firsthand interviews with experienced teachers (Demircioglu & Ucar, 2015). Essential to the development of a convincing paper are a clear focus on the issue at hand, which should appear in the opening thesis, followed by equally focused arguments supported by data, and organized in a coherent flow that leads to reader to a clear and concise conclusion (Creswell, 2012).

Position Paper as Effecting Social Change

The genre of this project, a position paper with recommendations, is a logical approach to effecting social change by "convincing others that we are right, modifying their representations or point of view, or influencing their judgments" (Coirier & Golder, 1993, p. 169). The social benefit being sought is improved training of mathematics teachers which may lead to greater student success. There is a strong relationship between education and improvement in citizens' lives, in that a community, such as a student body, must be "educated for change" (Lovett, Clarke, & Kilmurray, 2018). Thus, the recommendations of my position paper are aimed at improving the quality of education for APS students, which could lead to improvement in their lives.

Importance of Teacher Input in Forming a Persuasive Argument

The goal of a position paper is to persuade the reader, in this case APS administrators, to accept an argument in favor of a particular position. Petty (2018) suggested that "attitude judgments are made in the context of a person's past experiences (p. 35). Most, if not all, school administrators started as teachers, so they share experiences with the teachers from whom data were collected and should be open to their suggestions (Beachum & Dentith, 2004; Tokel, Dagli, Altinay, & Altinay, 2019; Vail, 2005). Tormala (2016) supported this concept of the importance of shared experiences, stating that "people assess their own certainty using informational and experiential inputs" (p. 6). My position paper combines empirical data collected from participants who share educational experience with the stakeholders receiving their suggestions.

The role of the MSP program was to improve a school's teaching quality. Teachers combine their knowledge of pedagogy and their knowledge of their course content to synthesize and deliver instruction to their students. Biesta (2015) argued that "if education requires judgement, … then it would follow that teachers have ample space and opportunity to exercise such judgement" (p. 81). This is the overarching premise of the position paper, to "bolster teachers' emergent understandings of standards and improve the likelihood of implementing instructional practices aligned to standards" (Allen & Penuel, 2015, p. 136). Administrators could find success in following the suggestions of their professional staff in how they want to improve their craft.

Recommendation 1: Continuing MSP-Style PD

The opening argument of my position paper recommended employing the MSP method for PD, as opposed to the current PD offered by the APS mathematics department. All participants in my research sample provided empirical data recommending that APS institute a PD program for mathematics teachers similar to the MSP program. Teachers reported that they found persistent PD, led by a college professor, over an extended period, more efficacious than other PD formats they have experienced. One salient aspect of MSP PD, sustained training, is an essential factor (Antoniou & Kyriakides, 2013; Bayar, 2014; Brownell, Hirsch, & Seo, 2004; Darling-Hammond & Berry, 2006; Foster et al., 2013; Salzman & Lowell, 2007).

These resources supported one element of the main argument of my position paper, the duration and persistence of training. The second factor identified in my research findings, high quality presenters, was also indicated in several scholarly works,

as essential to efficacious and long lasting teacher training (Childs, Barrett, Toma, & Troske, 2015; Childs & Russell, 2017; Copur-Gencturk, 2015; Gee & Whaley, 2016; Wiggins, 2017).

Overview of the Problem

APS desired to improve the mathematics achievement of their students in order to keep pace with the increasing technical demands of employment in their region. To accomplish this goal, APS participated in the federally funded MSP PD program, which provided monthly day-long instruction for mathematics teachers over a 3-year period. Lessons were taught by college professors as well as fellow public school teachers and included content instruction as well as exercises to improve pedagogy.

Scholarly researchers discussed in their literature the effect of PD on improving teachers' pedagogy and content knowledge, and its effect on student achievement in mathematics. Researchers sought to find a direct correlation between PD and improvement in student outcomes in mathematics, and divergent conclusions emerged among researchers' findings. Many researchers found that their data indicated measurable improvement as the result of well-designed and persistent PD (Capraro et al., 2016; Kutaka et al., 2017; Nadelson et al., 2012; Polly et al., 2015), and many found little or no correlation (Aladjem et al., 2010; Garet et al., 2016, 2011; Grigg et al., 2013; Harris & Sass, 2011; Hill, Rowan, & Ball, 2005; Polikoff, 2015).

Kutaka et al. (2017) observed that: "In the field of education, researchers often struggle to connect the impact of teacher PD to significant gains in student achievement; it is not always clear whether lack of student gains is due to a failure of the PD or other

intervening factors such as the instruments not fully capturing student change" (p. 150). One specific counterintuitive finding of note is: "On average, treatment teachers' students scored 2 percentile points lower than control teachers' students on both spring 2014 student achievement measures" (Garet et al., 2016, p. ES-8). Many researchers found significant to modest improvement in teachers' performance as a result of PD, and a lesser improvement in student achievement.

Action Proposed in Position Paper

Teachers participating in this study uniformly requested that APS administrators fashion subsequent PD in the format of the previous MSP training. In addition, several teachers indicated the benefits accrued to them by training in new technologies, especially the Nspire calculator. Recent scholarly studies suggested that use of the Nspire calculator improved student outcomes (K. K. Hill, 2018; Karadeniz & Thompson, 2018), and one paper indicated significant improvement (Bicer & Capraro, 2016). The anecdotal responses of participants in this study indicated that this training led to higher student achievement.

Needed Resources

In order to achieve desired outcomes, administrators, presenters, and participants must agree and collaborate to provide adequate physical materials such as projectors, printed materials, calculators, and other working tools. In addition, administrators must provide adequate paid planning time, adequate training time, suitable location, and adequate staffing of high-quality presenters (Darling-Hammond & Gardner, 2017). Follow-up in-school support, such as academic coaching, is needed to maintain and

refresh previous learning (Dudek, Reddy, Lekwa, Hua, & Fabiano, 2019; Rodgers, Kennedy, VanUitert, & Myers, 2019; Sayler et al., 2013; Stormont, Reinke, Newcomer, Marchese, & Lewis, 2015). Without proper implementation, even a carefully designed PD program might fail.

Existing Supports

APS schedules several days during each school year for PD for their professional staff, and several APS high schools have collaborative agreements with local higher education institutions. APS has included in its 2019-2020 proposed annual budget funding for instructional coaches in individual schools, who can provide school-based PD, as well as district wide, formally scheduled PD.. APS has forged close working relationships with most universities and colleges in its region, thusly facilitating finding college-level presenters for PD (Gardella, 2014). The major building blocks are already in place to execute these recommendations.

Potential Barriers

School administrators are entrusted by their tax paying public to provide cost-effective training for their teachers, so they must be judicious in their allocation of finite resources (Bifulco & Reback, 2013; Foster et al., 2013). The introduction of Common Core standards, funding pressure for an upsurge in teacher retirement pensions, and having to share budget funding with charter schools has placed additional strain on allocating adequate resources for PD (Darling-Hammond & Gardner, 2017). Probative findings in this study may guide administrators to more efficient use of their limited funds.

Potential Solutions to Barriers

The MSP program was primarily funded by federal grants (Sriraman, 2013). Local colleges might offer their staff at the college's expense, since their instructors benefit from direct collaboration with practicing teachers who share their insights and classroom experiences (Jones & Pepin, 2016). Perhaps APS could reach out to local industry, state government, or local universities to assist in funding or providing support in-kind.

Proposed Implementation

Teachers in my research sample reported that APS currently provides several days per school year of formal PD, and that in addition, most schools have full-time or part-time mathematics coaches. What appears to be missing in implementing the policy recommendations suggested by their teachers is the adoption of a clear vision, shared by faculty and administration, and the motivation to execute a PD program with uniform standards (S. J. Ball, Maguire, & Braun, 2011; Darling-Hammond & Gardner, 2017; Wei et al., 2009). This policy proposal provides a framework, suggested by professional mathematics educators, upon which all parties can agree and move forward.

Roles and Responsibilities

The recommendations included in this position paper are primarily addressed to APS administrators, but several levels of authority can play a role in successful implementation. Federal and state agencies can offer grants and specific funding for mathematics PD, as they provided previously to support the MSP program (Honey, 2016). Industries and organizations already collaborating with APS can offer additional

support specifically for the recommended mathematics training (Camacho & Alexandre, 2019; Plewa, Galán-muros, & Davey, 2015). APS administrators, mathematics department supervisors, and in-school coaches can adopt a common focus to extend the goals and techniques of MSP-style PD uniformly, consistently, and persistently, throughout the APS district.

Feasibility

Important criteria for a policy recommendation are purpose and feasibility, because the intention of this genre is to induce the audience of the position paper to take action; therefore, they must have the authority and the means to effect this change (Badger & White, 2000; S. J. Ball et al., 2011; Ngo & Melguizo, 2016). Feasibility analysis of a project views the technical aspects of a project in order to assess the practicality, the physical or financial possibility of launching a project, as well as its acceptability that it will be put to proper use by its recipients (D. Barrett, 2017; Bartlett et al., 2018; Fink et al., 2016; Hyman, 2018; Mesly, 2017; Rothstein et al., 2016; Smelror, Bless, Hugdahl, & Agartz, 2019). Certainly, the purpose of the project is clear, but its implementation requires a feasibility study.

The primary recommendation of this position paper is the continuation of PD for mathematics teachers in a format similar to that of a previous PD series. Because APS already provides ongoing PD for mathematics teachers throughout the school year, it is reasonable to recommend that administrators select the style of future teacher training to emulate that recommended by their professional faculty. This modification may incur

modest additional expense, but the bulk of the funding would have already been designated, keeping the policy recommendations feasible.

Hyman (2018) recommended the use of a pilot project which would precede a more detailed feasibility study. Although a pilot project may be superficial, it could reveal unforeseen impediments and sample acceptability. Since APS provides regularly scheduled PD for its mathematics teachers, instituting a pilot project could be informative and develop interest in following the recommendations gathered from their teachers.

Feasibility Assessment

APS administrators could employ a pilot project such as a modified MSP formatted training session, to assess the feasibility of the recommendations included in my position paper. Two elements of this pilot project to analyze are the adherence rate, the degree of participation and attendance, and the acceptability rate, the degree of satisfaction recorded by participants in a departure survey (Du, Venkatakrishnan, Youngblood, Ram, & Pirolli, 2016; Zylowska et al., 2008). The risk to APS is small since the greatest expense, the salaries of the participating teachers, is already committed. Only the nature of the presentation and the cost of an outside presenter are additional.

It is important to note that a feasibility study and a pilot project cannot assess efficacy of a larger project. Limitations result from the size of the sample, likely sample bias in assembling a trial, and lack of rigorous protocols in the design of an informal pilot (Hyman, 2018; Paneroni et al., 2015; Zylowska et al., 2008). A pilot could provide important data, especially from exit interviews with participants, upon which to refine a

more rigorous feasibility study, or it could lead directly to adopting the full recommendations of APS teachers in reformatting PD in the style of MSP.

Steps in Implementing a Feasibility Study

In order to act upon the recommendations of their teachers to improve PD, administrators would have to forge a new relationship with a local university to provide a leader for the PD sessions. Nationwide, a number of universities have partnered with local public school districts to share resources in training new teachers as well as improving existing teachers (Coffey, Putman, Handler, & Leach, 2019; Skinner & Williams, 2018; Smith et al., 2018). APS has already established partnerships with most local universities and colleges to supplement education choices for their students. Adding this one additional piece should be a low barrier to overcome. Acting upon the second recommendation, to discontinue use of EngageNY materials is a very high barrier, fraught with political pressure. It is far less likely that administrators would actuate this change without additional motivation.

APS administrators could solicit volunteer participants in a pilot PD session on a regularly scheduled training day, with the goal of assessing the degree of participation and satisfaction in the presentation (Martin, Stelfox, Gaihre, Morrison, & Smith, 2019). A professor from a local university, especially one of the presenters of the original MSP program at APS, could be hired for the day. Three important steps in designing a pilot project and collecting data are: first, adherence, the rate at which those invited to participate choose to attend, second, providing the physical and financial resources to offer a pilot training session, and third, evaluating acceptance by collecting exit data from

participants (Carandang & Pyatak, 2018). These data should be reasonably attainable with a limited sample, such as in a pilot study.

Project Description

This position paper identified strengths and weaknesses in a past MSP PD program from the perspective of its participants. These educators offered suggestions for improvement in future PD and additional suggestions to administrators regarding CCSS curriculum materials. Problems and solutions included in this position paper were based on firsthand data collected from this selected sample of teachers who attended the MSP program and who were still teaching in APS classrooms when interviewed. Data collected from participants were recorded, transcribed, member-checked, sorted by theme, and organized into a position paper to be presented to APS administrators.

Position Paper with Recommendations

The goal of this study was assessing the sustainability, the enduring improvement in teaching, as a result of the MSP program, from the perceptions of its participants. Qualitative data from interviews with past participants of the MSP PD program were organized and analyzed to develop a position paper to present to APS administrators. The project of this study is a position paper including empirical information in the form of statements from interviewees detailing the benefits and deficits of their past MSP training. More importantly, this position paper emphasized their suggestions for improvement of future PD, as well as recommendations regarding curriculum and educational materials.

Project Evaluation Plan

Project evaluation is an assessment of the results of an ongoing or completed undertaking compared to its goals at the outset. The Center for Disease Control prepared an extensive guide to aid their many constituents in evaluating various projects throughout the U.S., which suggested the four most common types of project evaluation: formative evaluation, implementation evaluation, outcome evaluation, and impact evaluation (Salabarría-Peña, Apt, & Walsh, 2007). I have selected formative assessment to evaluate my project.

Feasibility Study

Formative assessment can be conducted in the form of a feasibility study to assess the readiness and availability of all acting parties, facilities, timing, and funding (Chen, 2014; Salabarría-Peña et al., 2007). Teachers participating in this study uniformly recommended that APS administrators should emulate the MSP program for future PD sessions for the mathematics department. To do so could involve federal, state, and local funding and restrictions, availability of times for regular training, extra compensation for participants and presenters, planning lessons, forging a partnership with a local university, and many more variables, all of which must coalesce for a successful PD enterprise. Although there are many variables to coordinate, they are all within the capacity of APS administrators to execute. It is the goal of this position paper to spur APS administrators to share the vision and recommendations of their mathematics teachers and take the necessary actions to effect the change suggested to help their teachers and students excel.

Pilot Project

One method of conducting an informal feasibility study is a pilot project (Bartlett et al., 2018; Burton, Pakenham, & Brown, 2010; Fink et al., 2016; Larsen et al., 2018). APS administrators already have a mandate to provide ongoing professional development for their faculty (Carney et al., 2016). Because they already provide training, a pilot program would modify a regularly scheduled session by formatting it in the style of MSP. This would entail hiring a college professor to lead the session and collect specific data before and after the training session.

Feasibility studies are limited in scope and application, and use a small sample to test the interest in a program, measured as the degree of participation, and the acceptability of the program measured as the degree of satisfaction of the participants, usually collected as an exit interview or survey (Fink et al., 2016; Paneroni et al., 2015; Rothstein et al., 2016; Smelror et al., 2019). During one of several annual conference days set aside for district-wide professional development, APS could invite its mathematics teachers to voluntarily attend a special pilot session. Data collected before, during, and after the pilot training session could provide important information to guide APS administrators in adopting or disregarding the recommendations included in the position paper attached as Appendix A.

Project Implications

A major change was taking place in the APS district, a new high-tech factory was under construction, and school administrators were determined to improve student achievement in mathematics so their graduates could avail themselves of these new

technology employment opportunities. Many APS students are impoverished, and this new employment could dramatically improve their lives.

The first step for APS administrators was to improve the effectiveness of their mathematics and science instructors (Foster et al., 2013). APS instituted mandatory PD for all high school mathematics teachers over a 3-year period under the auspices of MSP. The MSP PD program was designed by the National Science Foundation to improve the quality of STEM instruction by funding teacher training led by a partnership of local professors and experienced mathematics coaches.

Addington has many job openings for those with technical skills, and many job training opportunities for students with functional mathematics skills. Improved PD for APS mathematics teachers could lead to greater achievement for their students in all of the STEM skills, science, technology, engineering, and mathematics. One study found that "high-quality PD is effective within the context of … diverse students from low-income families. This finding has important implications for national and state educational policies and efforts to improve STEM-oriented learning for all students" (Capraro et al., 2016, p. 193). Thusly, local stakeholders can help rebuild the Addington community with good jobs and well-educated students by accepting the recommendations of the teachers included in the attached position paper.

Section 4: Reflections and Conclusions

Project Strengths and Limitations

Although school district leaders have finite resources and many demands on their budgets, they should consider PD of teachers for it has been demonstrated to be a doubly effective long-term investment. Teachers retain benefits of their training over a period of years, and achievement gains resulting from improved teaching are maintained by students over their educational careers (Childs et al., 2015). These benefits necessitate paying presenters, having teachers attend the training, hiring substitute teachers to replace teachers in training, and incurring reporting and assessment expenses and facility costs (Odden, Archibald, & Fermanich, 2002). Fiscally responsible administrators need credible data upon which to make planning decisions about PD opportunities for their teachers.

Strengths

Using the database of participants' direct statements, I was able to analyze my findings and synthesize arguments for improvement of future PD for mathematics teachers. School administrators in most districts could benefit from data analysis, such as that presented in the position paper, to guide them in executing educationally effective and cost-effective teacher training (Marsh, Bertrand, & Huguet, 2015).

The project includes two recommendations: offering future PD following the format of the MSP program and allowing teachers to modify mandated teaching materials. One salient theme that emerged from analyzing collected data was the strong preference for a highly trained presenter, such as a college professor, to lead the PD

program. Participants' unified preference for this type of presenter should guide administrators' development of successful training as perceived by practicing mathematics instructors.

Limitations

The second recommendation, concerning the selection of instructional materials, is fraught with outside political considerations. Commenting on the nationwide introduction of CCSS instruction, Tampio (2017) noted that "the alignment of the SAT and ACT tests with the Common Core mean[s] that students must focus on the Common Core K-8 standards to graduate from high school" (Tampio, 2017, p. 1090). Public support for CCSS is slipping, but a 2016 nationwide poll of school districts found support levels still at 65% for maintaining the CCSS curriculum (Henderson, Peterson, & West, 2016). Regardless of the suggestions of their teachers, APS administrators might be reluctant to break away from CCSS and use of its recommended materials.

Recommendations for Alternative Approaches

An alternate approach schools might consider is greater use of online resources. Online courses are readily available for students; Khan Academy, for instance, boasts millions of lessons administered worldwide for free (Noer, 2012). Gamification is an attractive element of this self-directed learning enterprise, though the author of one controlled study found no student improvement when using this platform for mathematics remediation (Kelly, 2018). The "flipped classroom" model of online instruction, which is essentially a short video demonstrating a single educational point, has demonstrated success in mathematics instruction, but with a major caveat, the student's self-regulated

competence (Zengin, 2017). Authors of a recent study found that students with strong self-regulated learning skills benefited greatly from online resources, but poorly self-directed learners scored the same on assessments as the control group with no online resources (Lai & Hwang, 2016). Many struggling APS students fall into the second category, as noted in teacher interviews presented in the position paper.

Scholarship, Project Development and Evaluation, and Leadership and Change

Rigorous scholarship requires following universal rules of data collection, analysis, synthesis, and reporting. Scholarly discourse requires what may appear to be stilted language, but care and precision in expression are essential to presenting factual findings without nuance. Detailed formatting and listing of references is tedious but allows other scholars to access the sources of information to expand their understanding (APA Publications and Communications Board Working Group on Journal Article Reporting Standards, 2008). The persistent demand that any statement be supported by data, synthesis, or a scholarly reference ensures that information contained in a scholarly work is factual and credible (Creswell, 2012). Recommendations must be creditable in order to be successful when enacted.

Learning and executing these rigors of expression has been a challenging and rewarding journey. I feel confident that I can tackle future research successfully and efficiently and intend to do so. Preparing a position paper as my project was a gratifying experience; my data were compelling and bountiful, allowing me to build a convincing argument and propose a functional solution. I plan to use these potent communication skills in the near future to develop a program to improve medical home instruction for a

growing number of APS students suffering from anxiety to the extent that they can no longer attend regular classes.

Reflection on Importance of the Work

Developing this research study and project was not a meaningless academic exercise. I interviewed practicing teachers, collected and analyzed real data, identified a real problem and offered real, actionable solutions. Based on my research, APS administrators need this information, and the teachers who participated in this study hope they accept their suggestions. I benefited immediately in expanding my expertise in collecting, analyzing, synthesizing, and reporting information, and I hope to benefit in the future as an APS teacher, through improved PD that may enable me to help my students achieve more.

Implications, Applications, and Directions for Future Research

There are many ways to view education. The ultimate aim of education in the eyes of John Dewey (1916) was the advancement of self and society, and the role of universal public education was to develop a nation of healthy, happy, and productive citizens. APS administrators and teachers maintain this mantle of responsibility against the constant pressure of socioeconomic decline. Karner (2017) proposed that our current urban school structure in the U.S. reinforces inequalities, suggesting that teachers teach differently in urban schools than in suburban schools by intent. My experience as an urban mathematics teacher differs from this theory. My research project is intended to further the lofty goal of improving PD of teachers, leading to greater student success for all students.

Although teachers and students are often studied and their data collected and analyzed *en masse*, teaching is most often a highly personal, one-on-one process (see Feuerstein, Feuerstein, & Falik, 2015). The role of a classroom teacher far exceeds the transfer of information to a student. Students need nurturing to make them receptive to new information. Many U.S. students enter school with the burdens of poverty, broken homes, homelessness, and learning disabilities (see Lavigne, 2014). The skill and sensitivity to impart hope and a desire for success may not be inherent in some teachers, but they are traits that can be fostered in a teacher through effective PD (Lavigne, 2014). Society would benefit from improved teaching as a result of improved PD.

The MSP PD program provided many insights to participating mathematics instructors to offer their students multiple paths of understanding, giving them tools to stoke the fire of interest in their students by making the abstract concepts of mathematics accessible. Ongoing research to assess the efficacy and sustainability of all aspects of PD might further this goal of improving teacher performance leading to greater student achievement. The research presented in this paper may lead to this positive outcome.

In my review of scholarly literature, I found very few longitudinal studies of the sustainability of PD (e.g. Aladjem et al., 2010; Capraro et al., 2016). Certainly this is valuable information for stakeholders to acquire in order to guide their selection and implementation of future PD sessions for their teachers. In this study, having several years of classroom application of the learning garnered during the MSP program was very informative. Teachers participating in the study reflected upon the source of many classroom activities and pedagogies they were using at the time of their interview and

realized that several were the direct result of the MSP training. These empirical data are included in in the position paper.

Conclusion

A group of experienced APS mathematics instructors unanimously recommended that their administrators model future teacher training after the format of the MSP program. It is my hope that APS will follow the recommendations of their teachers found in this study and in its position paper, and they will strive to maintain highly effective PD.

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Appendix A: The Project

I prepared this position paper with recommendations for the Addington Public Schools (APS) administrative board.

Introduction

To prepare teachers for greater effectiveness in teaching science, technology, engineering and mathematics (STEM) subjects, APS provided 3 years of PD for mathematics and science teachers under the Mathematics and Science Partnership (MSP) program (Gersten, Taylor, Keys, Rolfhus, & Newman-Gonchar, 2014). The MSP program was created in 2002 as a new departure born of No Child Left Behind and nurtured under Race to the Top, to bolster American competitiveness, particularly in math and engineering, areas of expertise desperately needed to further new technical and industrial advances. MSP is a professional development (PD) program designed by the National Science Foundation to improve the quality of STEM instruction by forging a partnership between K-12 schools and their local universities (Foster, Toma, & Troske, 2013). The U.S. Department of Education has invested well over $70 million in grants to fund over 100 of these partnership PD programs (Honey, 2016). Foster et al. (2013) cited a report from the Government Accountability Office identifying overlapping federal expenditures to improve math instruction exceeding $3 billion by 2010.

Scholarly literature has addressed the challenges of implementing effective PD and sustaining its efficacy after cessation. Eisenhart et al. (2015) found that in two large urban school districts, PD programs demonstrated short-term improvement in student

outcomes, but these gains failed to persist. Factors that directly inhibit sustainability have been difficult to identify because rigor is lacking in many studies, leaving sustainability as a hidden but increasingly critical issue (Century, Cassata, Freeman, & Rudnick, 2012). There is therefore a general need for further study and a critical local need to collect more empirical data to find a clearer path to improving the sustainability of PD in STEM education (Bayar, 2014; Hacker, 2016; Piasta, Logan, Pelatti, Capps, & Petrill, 2015; Tricarico, Jacobs, & Yendol-Hoppey, 2015). Highly trained experts in education, such as teachers who completed the MSP training program, can offer a wealth of information through qualitative analysis of their perceptions of their MSP training and their recommendations for its improvement.

The goal of my study was to uncover and share with administration the experiences and advice of its practitioners, the mathematics teachers who attended the PD sessions and then deployed this new content knowledge and improved pedagogy in their classrooms. In this research project I collected and interpreted data in the hope that a report of my findings might effect positive social change by assisting APS administrators in enhancing the training of their mathematics instructors, which, in turn, might lead to improved mathematics accomplishment by APS students. Closing the existing mathematics achievement gap may open employment and college opportunities to APS students which can allow them to escape poverty and lead more successful lives.

Qualitative data were collected by interviewing 7 mathematics teachers who had participated in the MSP PD program from 2010-2013, and who were still teaching in the Addington Public School (APS) system. Teachers were interviewed to gain their

perspectives regarding this PD program, with special emphasis on its longevity, following Kleining's system of inquiry (Kleining & Witt, 2000). This heuristic framework allowed me to assist the participants when necessary to refresh their memory of their PD because they attended several years ago, and they sometimes needed clarification and affirmation that they were recalling the training from specifically the MSP program and not a subsequent PD event.

The Problem

Many participants in the MSP PD program had difficulty identifying benefits that they gained from their training that they still used in their classrooms. Important data were collected from participants in the form of suggestions to administrators to improve the immediate and longer-term effectiveness of PD of mathematics teachers. Teachers also offered suggestions to administrators regarding the applicability of Common Core State Standards (CCSS) and EngageNY materials to their classrooms.

The overarching research question of this study was teachers' perceptions of the sustainability of their MSP PD, which ended 5 years before these data were collected. Interviewees' verbal responses to my interview protocol elicited a broad spectrum of perceptions, with some teachers reporting that they gained much useful information and improved their pedagogy, while others felt that much of their time was wasted, and their students suffered from their absence from their classrooms on a recurring basis over 3 years. Suggestions to reduce teacher absence from the classroom and reduce this discontinuity in classroom routine were also offered by participants and are included in these policy recommendations.

Common Core State Standards were being introduced nationwide at the time of the MSP training, and the actual change in curriculum and teaching materials were enacted shortly thereafter. Teachers participating in this study were asked: "Did the MSP training prepare teachers adequately to integrate the new standards and teaching materials? Were teachers better prepared for the transition as a result of this PD? Did the content knowledge and pedagogy training result in improved student outcomes as the CCSS was introduced?"

Review of Scholarly Literature

Authors of the scholarly literature included in my research studied the effect of PD on improving teachers' pedagogy and content knowledge, and its effect on student achievement in mathematics. Researchers sought to find a direct correlation between PD and improvement in student outcomes in mathematics, and divergent conclusions emerged among researchers' findings. Many papers found that their data indicated measurable improvement as the result of well-designed and persistent PD (Capraro et al., 2016; Kutaka et al., 2017; Nadelson, Seifert, Moll, & Coats, 2012; Polly et al., 2015), and many found little or no correlation (Aladjem et al., 2010; Garet et al., 2016, 2011; Grigg, Kelly, Gamoran, & Borman, 2013; Harris & Sass, 2011; Hill, Rowan, & Ball, 2005; Polikoff, 2015).

Kutaka et al. (2017) observed that: "In the field of education, researchers often struggle to connect the impact of teacher PD to significant gains in student achievement; it is not always clear whether lack of student gains is due to a failure of the PD or other intervening factors such as the instruments not fully capturing student change" (p. 150).

One specific counterintuitive finding of note is: “On average, treatment teachers’ students scored 2 percentile points lower than control teachers’ students on both spring 2014 student achievement measures” (Garet et al., 2016, p. ES-8).

Research Question 1: Value

Scholarly Literature

The MSP program required teachers to be removed from their classrooms on a recurring basis which was a significant expense for APS and an inconvenience felt by most interviewees. Teachers in studies of other school districts reported that their employment did not provide adequate time away from the classroom or other necessary supports to allow them persistent PD (Gee & Whaley, 2016). Polly et al. (2015) indicated that the constraints of limited time made it more difficult for teachers to implement new learning into the classroom, modify lessons to exploit new approaches learned, and perform assessments on students before and after training to measure improvement in achievement as a result of PD.

APS is an urban public school system with predominantly impoverished students. Urban teachers may feel a greater need for PD for a variety of reasons. Many new teachers find their first job in a difficult urban school, because teachers leave these challenging positions for more attractive opportunities, thusly creating frequent vacancies which are often filled by inexperienced teachers. Urban students often have difficulties outside of school due to their socioeconomic status which impedes their progress in school. In addition, the new CCSS curriculum is more challenging academically than its predecessor, which led to the finding that “only 50% of teachers working with low

socioeconomic status students felt very or fairly prepared to teach the CCSS (Davis, McDuffie, Choppin, & Drake, 2017, p. 240).

Research Findings

The general response of teachers was split between those who felt they received great value, which was well worth the effort and expense, and those who felt their time was wasted. There were several expenses involved in attending these training sessions, but most teachers identified the mid-week interruption of their weekly lesson, and its incumbent effort in preparing a lesson to be administered by a substitute teacher, as major personal drawbacks.

Some teachers felt very strongly that the improvement in their content knowledge and insights gained in their pedagogy far outweighed the inconvenience and extra work needed to attend the training sessions. To preserve confidentiality, teachers are identified as T1, T2, etc. in this study. Qualitative data collected included statements such as "value was so much more than the work involved to attend" (T1), "I definitely think it was worth it…I learned a lot, stuff that I could use in the classroom right away" (T7), and "I thought that the MSP was definitely worth it,…I find PD always to be useful. I learn a tremendous amount from it" (T2).

Some teachers were more equivocal in their response, such as "40-50% of what we gained was worth the time invested, but the remaining 50-60% wasn't worth the time out of the classroom" (T4), and "I hate missing class, but any opportunity to reflect on our craft even if it's bad PD which (the instructor) would never give bad PD, she's a class act, but even from bad PD you still get a chance to reflect and that has value" (T5). And

some participants were clearly negative in their response. One teacher felt that he had already mastered the material presented "It wasn't worth it to me, I had much of the material before in college, I was exposed to a lot of that I graduate school. It wasn't very informative for me" (T5). Another decried the great disruption in his classroom "I never like to be out of my classroom unless it is absolutely necessary, so...unless it is something completely above and beyond, something impactful or so immediately implementable in the classroom, I don't like to disrupt the continuity of the week" (T6).

Most interviewees had little comment on the financial cost of the program, but some viewed the MSP program as a good value, "Now I can say I think money is wasted on some training…and 10 years later I am still NOT saying that about the MSP grant" (T1). Some clearly felt otherwise, "A good return on your investment? No. Maybe 10% return on the value of my absence" (T6).

Research Question 2: Applicability

Scholarly Literature

In order for PD to effect change in the classroom, it must directly correspond to the needs of the teacher, the students, and the curriculum taught (Ball, Thames, & Phelps, 2008). Teachers may be trained to implement the most current pedagogy using the most advanced technology, only to return to their classroom with outdated textbooks and failing calculators, relying upon free lessons downloaded from internet sources (Davis et al., 2017).

Reaching deeper into applying PD to the transition in the classroom to the new CCSS standards, teachers found themselves assembling sparse new materials into their

own iteration of a standards-aligned curriculum and relying heavily on their PD standards-aligned training (Johnson, Severance, Penuel, & Leary, 2016). To compound this challenge to applicability, teachers reported their lack of familiarity with the new CCSS standards of assessment and evaluation (Davis et al., 2017). One finding of note is "math content knowledge and dimensions of instructional practice targeted by the training did not directly correlate to lessons being taught in the classroom" (Garet et al., 2016, p. ES-9).

Research Findings

One salient theme that emerged from my data collection was teacher engagement in training and implementation of the Nspire calculator system. Almost every teacher mentioned their lessons on the calculator favorably and that they were able to use it in their classroom (not every teacher received a classroom set of new calculators right away) and that this aspect of the MSP program is still in use. T7, an experienced teacher with advanced degrees, expressed the value of his new calculator training thusly: "Our students being able to graph functions and compare relationships on the calculator…being able to display their knowledge using the Navigator…it's something the kids could use immediately, it made their learning a lot easier." T1, a new teacher at the time of the MSP training reiterated "The thing I remember the most was the calculators, they are an important part of being a math teacher. The technology changes but a lot of what we did with the calculators was essential."

Not every teacher felt strongly about the benefits of the calculator training. T4 stated that "I invested hours and hours and hours to understand, but my working

knowledge could have been much better the first two years I used them (the Nspire calculators) had the training been more effective." T3 reported that he felt he benefitted from the calculator training, but not to the extent of others, and his school has not yet adopted the new calculators. T6 took a broader view of the topic of technology in the classroom training, opining that "Technology is great, calculators are great, but it doesn't erase the underlying variables that contribute to education…it doesn't erase poverty, it doesn't erase absenteeism, or any of those major issues that teachers always have to battle with."

Research Question 3: Longevity

Scholarly Literature

Several researchers explored the extent to which the benefits of training persist within the teacher and within the classroom. Salzman and Lowell (2007) argued that their data indicated that PD of teachers had worked well in the field of science, and that US students are, for the most part, not lagging behind those of other nations. Capraro et al. (2016) reaffirmed this position, and indicated that improvement or at least stasis has persisted for ten years since the 2007 study. Salzman and Lowell did add that lower performing students were definitely in need of greater academic support and suggested greater PD to achieve this.

The length of training may affect the length of its continued benefit. Gee & Whaley (2016) found in their study that a continuous process of professional learning needs at least two years in order to deepen teachers' understanding of mathematics and pedagogy. The quality of the training is of course essential, to the extent that "sustained

and systematic high-quality, research-based PD…could lead to major student learning gains…this study shows that low-quality implementation of a new initiative actually hurt student learning" (Capraro et al., 2016, p. 192). Teachers prefer longer training periods, especially those including university participation, which was an essential element of the MSP training (Knowlton, Fogleman, Reichsman, & de Oliveira, 2015).

Research Findings

Some teachers had clear memories of individual lessons as part of MSP training, but most had little or no specific recollection, without prompting. Several interviewees indicated that over the past several years their mathematics department had provided many different PD opportunities, although none were comparable in the frequency, intensity, and 3-year duration to the MSP program. In spite of the magnitude of the MSP program, several teachers struggled to recall specific lessons included in the PD program. Some teachers, upon reflection, realized that lessons they were using currently in their classrooms originated from their MSP training.

T1 recalled "You know, I still use them and that MSP grant, was it 10 years ago? And I still remember one of those handouts…a scavenger hunt on how to find different buttons on the calculator, how to find different options. And that goes back to MSP training". This refers to a lesson T1 still uses in classes to familiarize his students with the calculator. T5 indicated "I'm having a hard time differentiating between the MSP program and the many other PD sessions we've had in the past…there have been a lot of different ones, and each one if feel had value." But then he paused and recognized that an entire trigonometry unit he had modified and shared with another teacher originated from

his MSP training. The teacher with whom he shared his MSP lesson shared it with others and "she's got that on her wall in the hallway, so not only did that affect me but that's also affecting other people …the next generation type thing" (T5).

Several teachers had faint memories of their MSP training, such as T3, "I have a hard time remembering some of our exercises in the MSP. I remember having a hard time with the white board and having to learn all the technology with the new calculators." T4 shared a sentiment expressed by others, "I'm having difficulty remembering specific examples, only because it was several years ago. Oftimes from training like this I incorporate pieces of training that are valuable, and I forget the rest." T6 stated more strongly that he remembered very little because he found it not applicable to his urban students. In a similar vein, T7 indicated that he forgot much of his MSP training over time because "There are a lot of things that I did not use right away because I did not teach that course or grade level for a couple of years and had since forgotten it."

Research Question 4: Efficacy

Scholarly Literature

MSP PD focused on both content knowledge and pedagogy in its day-long lessons. Many resources used in my study indicated that the dual emphasis included in MSP training "advances the knowledge base on the influence of content knowledge and teachers' beliefs on student achievement" (Polly et al., 2015, p. 26), leading to sustained significant improvement in student outcomes.

One caveat to linking effectiveness in the classroom to the quality of the PD is teacher attitudes and beliefs. In the period of transition to CCSS which began on the tail

of MSP training of APS teachers, teachers' understanding and acceptance of new academic standards and its incumbent change in emphasis ultimately effected the execution of those standards (Johnson et al., 2016). Similarly, Burrows (2015) identified self-efficacy as an essential catalyst to turn productive PD into effective PD.

The emphasis on mathematical content knowledge was acknowledged in several scholarly papers as an essential element of efficacy. Having teachers work with college professors on mathematics gave the teacher the opportunity to become the student, leading to a greater understanding of student thinking and analysis of problems. These classroom skills included formulating algebraic expressions from real-world problems and sharing and critiquing explanations (Ball et al., 2008). This exposure to the developmental process of learning in a collaborative environment furthered their deeper assimilation of the pedagogy while strengthening their command of the content (Kutaka et al., 2017).

Research Findings

The MSP program was manifold in that it focused on reinforcing content knowledge, demonstrated a variety of pedagogical techniques, introduced new technologies, especially the Texas Instruments Nspire calculator, and introduced the impending CCSS transformation. Interviewees were queried over this broad palette of potential growth in their classroom effectiveness and asked to provide examples of successes and failures in classroom application and student outcomes.

T7 felt very strongly that his training was efficacious in that what he learned about new technologies, and especially the new calculator, he was able to share with

other teachers, and they benefited from his MSP training. T5 found efficacy in the method of presentation, that "In our class we learned more through reflection. I imagine they gave us free time at our tables to reflect, to make a poster, put something on a Post-it note…some kind of reflection. If they did that, they built my pedagogical muscle."

One teacher who had mostly negative regard for the MSP training did incorporate an important emphasis of the MSP program into his general pedagogy "I do remember one teacher who presented an example of how he had turned his classroom into learning centers and had the same material presented in a variety of different modes and he really explained how and why he constructed it and how it was used. He showed a videotape, that was a very useful lesson" (T4). This same teacher found himself inspired by this learning center concept, even though he has not yet been able to incorporate it into his classroom.

In addition to strategies learned to improve content knowledge and pedagogy, efficacy of this training regimen included the extent to which a participant changed how he views his job as a math teacher. T5 stated frankly that "There were some teachers who were just complaining the whole time, but it opened my eyes that it got me from where I was to where I am today." He also added later in the interview that "I imagine you would have to attribute some of the growth to the three years of MSP because we learned a lot inside the classroom, but we also learned a lot of pedagogy."

T2 did not think MSP changed his view of his job, but later reflected upon the enthusiasm shared by his cohort and "having a high for a week or two after one of those trainings. Of just being really happy to be in the classroom, of being excited about the

content, showing my students ‘oh I just learned the neatest thing yesterday, look what we can do now!’” T1 was a new teacher at the time of MSP and felt more accomplished as a teacher after having a regular time and place to ask questions of experts. He also felt that reviewing the content of each math course, Algebra 1, Geometry, and Algebra 2, was very reassuring, because as a new teacher “you find out what you will be teaching the first day of school most of the time, and you have no time to prepare.”

Recommendations

Recommendation 1: Continuing MSP-Style PD

APS should provide mathematics teachers with regular, ongoing PD similar to the MSP program. Teachers participating in this research project uniformly favored instruction led by a highly trained professional such as a college professor, especially for content knowledge. Interviewees indicated that new technologies should be introduced by a highly trained specialist such as a mathematics coach or a manufacturer’s representative. Most teachers responded vehemently that their training in CCSS and EngageNY materials was insufficient and poorly presented, to the detriment of their students.

Recommendation 2: EngageNY Materials Made Optional

After collecting qualitative data from teachers regarding the MSP PD program, they were encouraged to offer their suggestions to administration to improve their craft and increase student achievement. They uniformly reported that EngageNY materials were not working well in their urban classrooms. They cited the lack of an index, glossary, table of contents, videos, online lessons, online assessments, and color

illustrations as major deficiencies. Most participants found that lessons took much longer than recommended to execute in the classroom, leaving no time for scaffolding or enrichment. Many teachers reported that they abandoned EngageNY materials partially or entirely.

Suggested Solutions

MSP-Style PD

Participants in this study strongly favored having lessons led by a college professor. APS could collaborate with a local college or university that offers courses in the teaching of mathematics. Their professors could lead the PD of APS teachers, and the professors' students could work in groups with the experienced teachers, sharing their classroom expertise.

Less Disruption of Classroom Routine

Some interviewees stated that being removed from their classrooms during normal instruction times on a repeated basis was disruptive to student learning. PD sessions could take place on conference days, already set aside for this purpose, and an additional 2-3 days evenly spaced throughout the school year. Other alternatives could be offering a 4-day session during the February break, or in August, shortly before classes resume. Of course, there may be contractual and payroll issues to resolve. Online courses prepared specifically for APS teachers, to be viewed during preparation time or common planning time might also be considered.

Discontinue Mandatory Use of EngageNY Materials

APS requires its mathematics teachers to use EngageNY materials in the classroom. Several teachers reported that these teaching materials lack many important features to help struggling students. Some states, school districts, and individual schools have abandoned CCSS curriculum and EngageNY materials. APS should allow tenured teachers, licensed practitioners who have already demonstrated success in their classrooms, greater latitude in selecting educational materials suited to their students and their pedagogy.

Conclusion

APS provided its mathematics teachers with three years of PD under the auspices of the Mathematics and Science Partnership with the immediate goal of improving classroom instruction leading to the ultimate goal of improving student achievement. Some teachers had vivid recollections connecting some of their favorite current classroom lessons directly to their MSP training and its incumbent collaboration among colleagues.

Several interviewees identified having a college professor provide much of the content knowledge and pedagogy instruction as a notable differentiating factor, elevating this PD program over most others. Over subsequent years, teachers received occasional PD sessions on calculator techniques and frequent sessions on CCSS lessons as they were introduced in stages. Many teachers commented that these subsequent lessons, most often presented by administrators or fellow teachers, were less compelling than their MSP training. Participants in this study generally found value in their MSP training, although

some questioned whether the benefits outweighed the expense of disrupting their classroom routine.

Teachers' perceptions regarding applying this these new strategies to the new CCSS curriculum was disjunct, primarily because of the EngageNY teaching materials that accompanied the new CCSS curriculum, rather than the curriculum itself. Some teachers found their new pedagogical approaches helped their students, but most teachers found the new lessons to be unusable, especially in an urban classroom, to the extent that they expressed that no pedagogy could overcome materials so devoid of content to help struggling students.

APS administrators are encouraged to accept the advice of their teachers to upgrade the quality of mathematics PD to that of the MSP program, to hold regular training sessions with limited disruption of classroom routines and reevaluate the use of EngageNY materials.

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Appendix B: Interview Protocol

Research interview questions

RQ 1: Value

How do teachers who participated in the MSP PD program perceive the value of the program as related to their personal effort, time away from class, preparation of work for their substitute teacher, travel to another location, and cost to the school and taxpayer?

- You spent one day each month away from your class for MSP training
    - To what extent was it worth the time
        - Prepare work for your substitute teacher
        - Grade papers upon return
        - Travel to a different location away from school
- This training was a significant expense of your tax dollars
    - To what extent did you feel you as a taxpayer received fair value of the cost of the MSP program
    - How did this training compare with other PD experiences—please share some examples

RQ 2: Applicability

How do teachers who participated in the MSP PD describe to what extent and in what fashion their new learning was related, pertinent, and significant to the curriculum they teach?

- **Common Core** Learning Standards were introduced immediately after MSP training
    - To what extent did your MSP training help ***you*** make the transition
        - Which new skills or knowledge did you employ to teach this new curriculum
        - To what extent did MSP provide all or some of this new information or technique
    - To what extent did your MSP training help you make the transition
        - Common Core demands deeper thinking and more writing
        - Many students are experiencing this new approach for the first time
        - To what extent did your MSP PD help you help your students

RQ 3: Longevity

How do teachers who participated in the MSP PD describe to what extent the benefits of training endured, and to what degree?

- MSP training ended a few years ago
    - To what extent did you benefit immediately after training
    - Did the training transfer to your classroom
        - Improved pedagogy
        - Greater teacher satisfaction/retention
        - Please share some examples
    - To what extent did the benefits of this program persist
        - To what extent did the benefits increase or decrease over time

RQ 4: Efficacy

What strategies do teachers who participated in the MSP PD program describe as improving their content knowledge and pedagogy?

- What were your perceptions of the impact of the Mathematics and Science Partnership program's PD sessions
    - To what extent did this training change how you view your job as a teacher
    - To what extent did this training change how you view your job as a math teacher
    - To what extent did this training change how you view mathematics
    - To what extent did this training change how you view mathematics and its relationship to science
- To what extent did this MSP PD program change how you teach
    - To what extent did you increase your content knowledge
        - Do you feel that you have greater knowledge of mathematics as a result of MSP training, and if so, do you perceive that it made you a better teacher—please share some examples from your classroom experience
        - To what extent did you feel you can transfer this knowledge to your students
        - If you feel you gained greater content knowledge, to what extent did it make you feel more comfortable or more accomplished in front of a classroom of students
    - To what extent did you increase your pedagogical knowledge
        - To what extent did you feel that what you learned in MSP about teaching made you a better teacher
        - Do you feel that your students might perform better and/or behave better as a result of what you learned in MSP—please share some observations
        - Could you share a few examples to illustrate significant changes in your teaching

RQ 5: Suggested Improvements

What improvements do teachers who participated in the MSP PD recommend regarding the MSP program, or PD in general?