THE BENEFITS OF A TEACHER-RESEARCHER PARTNERSHIP ON THE IMPLEMENTATION OF NEW PRACTICES IN THE MATHEMATICS CLASSROOM

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ABSTRACT

Implementing research-based practices in classrooms as a means of increasing achievement in mathematics for all students requires an understanding of many complex factors that influence classroom change. Situating the role of the teacher as critical to these efforts, teacher inquiry provides a theoretical framework from which to understand the importance of teacher-created knowledge in implementing new instructional practices. A teacher-researcher partnership may provide the support system for teacher inquiry to occur. This study investigated the effects of a research partnership on the implementation of research-based practices, specifically considering the views of teachers participating in the partnership, the differences in implementation based on interactions with researchers, and the features of the partnership that supported the implementation of new practices.

Interpretative Phenomenological Analysis of secondary data was used to understand the experiences of twelve teachers who participated in a research partnership among a research-based non-profit, a national coalition of public schools, and two universities. Results from observation, survey, and interview data found teachers had a complex self-perception of their own roles in the teacher-researcher partnership including being a collaborator, a learner, and an agent of change. Additionally, teachers who interacted with researchers embraced the new materials and instructional practices more so than those who did not. Features of the partnership that were supportive of the implementation process included a focus on the teacher, evolution and responsiveness, and collaboration and integration. Implications for teachers, researchers, administrators, and others are discussed.

To all of my former students,

you are my passion and inspiration.

To all students of mathematics,

may you each receive amazing opportunities

to learn and love mathematics.

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CHAPTER 1

INTRODUCTION

Albert Einstein famously defined insanity as "doing the same thing over and over again and expecting different results." With student performance in mathematics, as measured from multiple sources over the last decade, demonstrating a national weakness in mathematics (Provasnik et al., 2012; OECD, 2014) and performance gaps remaining stagnant among students of different races and among students from different socio-economic statuses (NCES, 2013), it is clear that mathematics educators cannot continue to do the same things over and over again.

Various international, comparative mathematics assessments evaluate the performance of students differently, but trends consistently show decreasing mathematics abilities of U.S. students by 8th grade (OECD, 2014; Provasnik et al., 2012). Additionally, the gaps that have existed in performance between students of color and white students and between students from low-income households and their peers, while decreasing somewhat, still persist (Berends & Penaloza, 2010; Lee & Reeves, 2012; NCES, 2013). It has long been documented that African American and Latino/a students score lower on mathematics tests and have less access to advanced courses, highly qualified teachers, and rich opportunities to learn mathematics than white students (Berry, Ellis, & Hughes, 2014; Flores, 2007); a similar trend exists for students coming from low-income households and for students who are learning to speak English (Boaler & Staples, 2008; Lee & Luykx, 2005; RAND, 2003; Slavin & Lake, 2008).

Therefore, considering the specific decline in mathematics performance as students reach middle and high school, a change in secondary mathematics instruction is needed to increase opportunities for high achievement in mathematics for all students, especially those who have previously had fewer such opportunities. Yet the question of how to do this remains.

Statement of the Problem

Existing efforts at improving mathematics education for all students have been met with mixed results (Vetter, 2012; Wilson, 2003), especially in high-poverty urban schools (McKinney et al., 2009). While many social factors may also affect student achievement, the focus of this paper will remain on factors that are within the control of an education system. One possible explanation for the absence of consistent implementation of improved mathematical practices could be a lack of focus on the role of the individual teacher. The importance of the role of the teacher in improving student outcomes has been well documented (Desimone et al., 2005; Jepsen, 2005; Penuel et al., 2011; RAND, 2003; Slavin & Lake, 2008), yet few models of classroom change are created with teachers playing integral roles in the design process. Teacher-researcher partnerships present an opportunity to close the research-practice gap in education and involve teachers in instrumental decisions that may affect the success of implementing new practices aimed at increasing students' success in mathematics.

The question then arises: Do teachers embrace change when they are a more integral part in designing it? Based on the work of Cochran-Smith and Lytle (2009), teacher inquiry in classroom change requires that teachers become creators of new knowledge and that this knowledge is shaped through collaboration when teachers address problems in their practice. If the role of the teacher is critical to reform efforts, and teachers themselves can generate meaningful knowledge to transform their classroom, collaboration between researchers and teachers could help facilitate the creation of meaningful, classroom-based knowledge in an efficient manner, employing the talents of both parties to best address educational challenges.

While significant research has elaborated upon different types of teacher-researcher relationships, little research has explored direct connections between research partnerships and teacher practices. Recalling the need for improvement in mathematics education, researchers do know that the role of the teacher in improving classroom instruction is critical. With mixed results about which types of changes work in all classrooms, it seems reasonable to think about classroom instruction individually, where the teacher's role is to adapt the best possible knowledge available to the needs of his or her students.

Combining the goal of improvement in mathematics education with the theoretical perspective that teachers should serve as a centerpiece to the creation of knowledge, teacher-researcher partnerships serve as a possible tool for lasting classroom change. A specific missing link, however, is the investigation of a direct connection between teacher-researcher partnerships and observable practices.

Background

Debate about the nature of mathematics education has oscillated between valuing computational skills and valuing contextual skills and understanding since as early as 1821, when Warren Colburn wrote *First Lessons in Intellectual Arithmetic*, articulating alternate teaching methods to the previously common rote memorization (Cooper & Null, 2011). Emphasizing understanding and making meaning out of mathematics, Colburn began a debate that has lasted for nearly two hundred years. Despite this debate and to the frustration of some mathematics educators, Suzanne Wilson (2003) concluded in 2003, "mathematics teaching remains much like it was in the mid-1800s" (p. 17). The years since she made her conclusion have given rise to the Common Core State Standards, which not only guide most mathematics content today, but also include key instructional practices. A brief history of mathematics reform efforts will provide context to the instructional change efforts being attempted today.

After decades spent in the early twentieth century focused on making mathematics meaningful to students by focusing on its applications, the World War II era brought a return to mathematical drills. The Cold War brought an emphasis on the changing nature of mathematics and the ability of students to adapt to rising technology, and the term 'New Math' was first coined. With attempts to focus on inquiry and understanding of structures, New Math was met with criticism and eventual failure, facilitating the swing back to a focus on the basics in mathematics education (Wilson, 2003).

The modern reform movement in mathematics education began with the publication of *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics (NCTM) in 1989. In response to renewed calls for improvements in math education, this document not only set forth a set of standards, practices, and assessment guidelines, it marked the next era of change in the world of mathematics education. This new vision for mathematics instruction included key focuses on problem solving, communication, reasoning skills, and mathematical connections (NCTM, 1989). In 2000, NCTM significantly expounded on this vision with *Principles and Standards for School Mathematics*, a document that extended and updated the mathematical standards and set six principles as the foundation of high-quality mathematics instruction: equity, curriculum, teaching, learning, assessment, and technology (NCTM, 2000). Whereas reform in math can occur around content, depth, or instructional practices (Wilson, 2003), much of the discussion since 1989 had focused on the practices.

Yet in 2003, Suzanne Wilson (2003) still concluded that "neither progressive nor traditional education has been implemented well on a large scale in the United States" (p. 217), suggesting that the debate about how to best improve education must go beyond *identifying* important mathematical practices and consider the *implementation* of these practices. One critical, but often overlooked, factor is the role of the individual teacher when implementing a new practice. Vetter (2012) suggested that even while teachers may attempt to use new strategies or practices, finding lasting change in the classroom "is difficult because it expects that teachers challenge and reconstruct deeply embedded practices and beliefs" (p. 27). Burns and Ysseldyke (2009) agreed that the role of the teacher must be central to any effort to change instruction because new practices can only be successful if they address "the attitudes, beliefs, and behaviors of those who actually implement the change…" (p. 4).

Similarly, based on her analysis of various mathematics reforms in California, Wilson (2003) concluded from her observations that "in the end, teachers will enact and mediate any effort to improve mathematics education" (p. 217). She described how "we are dependent on teachers – they are necessary agents of reform…" (p. 218). Cochran-Smith and Lytle (2009) agreed, noting, "teachers and other practitioners are the key to educational change" (p. 1). Their observations are echoed by many researchers who have found that the actions of teachers have the greatest impact on improving student achievement (Desimone et al., 2005; Jepsen, 2005; Penuel et al., 2011; RAND, 2003; Slavin & Lake, 2008). Teachers, therefore, have a critical role in implementing practices aimed at improving mathematics education (Ball, 1996; Desimone et al., 2005; Rand, 2003; Slavin & Lake, 2008).

One reason the roles of the individual teachers are critical to implementation efforts aimed at improving mathematics education is that they have been found to have the greatest impact overall on student achievement (as measured by state standardized tests) when compared to the effects of curricula, textbooks, and other learning-based tools. In a review of elementary mathematics programs, Slavin and Lake (2008) examined the impacts of textbooks and curricula, technology, and instructional practices on various measures of mathematics learning. They found no significant effects from textbooks or curricula, mixed effects from technology, but overwhelmingly positive effects for "teachers' instructional behavior" (Slavin & Lake, 2008, p. 481). They concluded that changing teacher practices is the way to affect mathematics achievement the most. Using multilevel modeling, Konstantopoulos (2011) found similar results. This researcher examined whether teacher effects – the differences that occur between teachers when all other variables are accounted for – predict student achievement over one or more years. His results indicated that both over one year and over multiple years, teacher effects positively and significantly predicted student achievement in mathematics.

From statistical measures to qualitative interviews, researchers have used various techniques to come to the same conclusion: student learning is most affected by teachers (Rockoff, 2004). Summarizing the view of many researchers, “teachers *do matter*” (Konstantopoulos, 2011, p. 1560).

Additionally, the importance of the role of the teacher when specifically implementing change has been well documented. While policy can attempt to dictate reform, teaching itself is an unpredictable component. Because of these uncertainties, implementing new practices must include significant work with teachers (Ball, 1996). In a review of literature to identify programs that have successfully improved educational outcomes, Penuel, Fishman, Cheng, and Sabelli (2011) found that it was the teachers’ adaptations of policy or reform that impacted the outcomes more so than the original plan itself. Similarly, in a study of 10 fourth grade teachers charged with implementing a program to improve the level of algebraic thinking involved in classroom mathematics instruction, Tunks and Weller (2009) bluntly explained that while high goals within a mathematics curriculum are great, true change “arises only when those ultimately responsible for instruction, the teachers” embrace those goals (p. 177). In a case study of a single teacher attempting to implement change in her fifth grade classroom, Vetter (2012) also identified the role of the teacher as central to the goals of reform. Ultimately, those who write curriculum, mandate policy, or suggest well intentioned reforms need to understand that the implementation of any given change rarely occurs in the classroom as written on paper. The teacher acts as the mitigating factor and is ultimately the one who determines the success or failure of any instructional reform (Handal & Herrington, 2003). The role of the teacher, then, becomes one of the most critical components to the success of any attempts to implement mathematics reform measures intended to provide opportunities for all students to learn mathematics; yet the role of the teacher is exceptionally complicated.

Sometimes, when confronted with the task of implementing new, high quality mathematics practices, teachers face challenges. Educational systems expect teachers to have a stable classroom. Yet change can have the opposite effect, and this is amplified when students and parents question the change and administrators have not fully supported teachers (Handal & Herrington, 2003). Besides student and parent protests and intolerant administrators, additional challenges include the time it takes to learn and plan something new (Ball, 1996), a group-wide culture of risk aversion (Ball, 1996; Huffman et al., 2008), a lack of resources needed for the new strategy, instructional pacing requirements (Huffman et al., 2008), or poorly planned or executed professional development (Hamilton et al., 2003; Hiebert & Stigler, 2000). Even when improvement plans for mathematics education do acknowledge the complex nature of teaching, many still struggle to adequately address all the needs of teachers. External factors are often, if not always, outside of a teacher's locus of control; however, internal, personal barriers can also impede the implementation of new practices in a classroom.

Such internal barriers for teachers include finding that these practices conflict with personal ideals (Desimone et al., 2005; McKinney et al., 2009), finding the new mathematics practices personally challenging (Ball, 1996; Desimone et al., 2005; Huffman et al., 2008), or finding that they become more challenging when they differ significantly from teachers' current practices (Nathan & Knuth, 2003). The conflict between the implementation of new classroom practices and personal ideals stems from how beliefs and attitudes of teachers mediate implementation. Handal and Herrington (2003) directly stated that teacher beliefs affect classroom practices, either facilitating or inhibiting the success of a new practice. The lack of success of an implementation of a new practice can occur when a teacher's belief system is not in accord with what the new practice requires or assumes. Not only are congruent beliefs with the current innovation critical to the success of the implementation, but future attempts at new practices can be negatively impacted by a mismatch between teachers' own beliefs and the rational that underscores a new practice (Handal & Herrington, 2003).

One example of a mismatch of beliefs, suggested by Desimone et al. (2005), occurs when teachers believe that conceptual and computational instruction are at odds with each other or that conceptual knowledge is more appropriate for high achieving students, while computational strategies are more appropriate for lower achieving students. These beliefs can be traced back to the debate about the nature of mathematics, and they affect the implementation of practices that focus on the integration of both conceptual and computational strategies for students of all ability levels. Similarly, the belief about what is important in mathematics education can often be traced to a teacher's experience as a learner, with the outcome frequently being a repetition of strategies that were used in an earlier era (McKinney et al., 2009). This becomes especially problematic, however, when the traditional strategies used to teach mathematics only reach a certain subset of students. With the focus of many new strategies in mathematics aimed at improving equity and providing students from all backgrounds the opportunity to learn high quality mathematics, the beliefs that diverge from the new practices can cause an interruption in the ability of new practices to be implemented in the classroom.

Ultimately, successful implementation is dependent on teachers' willingness to embrace new practices.

Another internal factor that affects individual teachers' implementation of new mathematics practices is knowledge, specifically mathematics knowledge for teaching (MKT). MKT has been found to impact instructional quality and student achievement (Hill et al., 2008). In a study of the mathematical quality of instruction and MKT of five different mathematics teachers, Hill et al. (2008) found "that there is a powerful relationship between what a teacher knows, how she knows it, and what she can do in the context of instruction" (p. 496). Much research has demonstrated that teachers with higher levels of MKT use instructional strategies that are supportive of tasks that require a higher cognitive load to be placed on students (Charalambous, 2010; Hill & Charalambous, 2012). However, the direct relationship between MKT and instructional practices is hard to differentiate as the "use of curriculum materials, beliefs about mathematics, and the effects of teacher professional development" (Hill et al., 2008) are all part of a complex system. Chick (2009) attempted to gain further understanding of the relationship between MKT and practices by examining one specific practice used in mathematics classrooms: the use of examples as explanatory tools. She found that "complex knowledge […] is required to choose and use examples effectively" (Chick, 2009, p. 29). To navigate all of the decisions that go into presenting mathematical content, "finding the right context, choosing appropriate numerical values, ensuring that the relevant is obvious and that the irrelevant can also be identified as such, and making the whole situation accessible for students" (Chick, 2009, p. 30) requires a high level of MKT.

Tasks associated with new reform initiatives (NCTM-based reforms or Common Core Standards for Mathematical Practice, for example) require more nuanced knowledge of how to manage students' explorations of higher-level content (Charalambous, 2012; Hill & Charalambous, 2012). With more focus on cognitively demanding tasks in mathematics classrooms, there has been increased interest in the impact of MKT on students' mathematical experiences. However, due to the complex nature of measuring the direct impact of MKT on teaching, many researchers have called for more nuanced analysis of the impacts of MKT on the entire process of classroom instruction (Shechtman, Roschelle, Haertel, & Knudsen, 2010). Hill and Charalambous (2012) suggested that having high MKT could support a teacher's ability to organize curriculum tasks that support student achievement. In an exploratory case study, Steele and Rogers (2012) explained their more thorough analysis of how MKT looks during an enacted classroom lesson. They countered the narrative that MKT alone doesn't correlate with student learning by explaining that both a clinical assessment and classroom observations can be used to measure "the ways in which teachers draw on their mathematical knowledge to make the set of instructional decisions that result in a particular lesson and, ultimately, student learning" (p. 176). While nuanced with a complex relationship, MKT may have an effect on the implementation of new practices specifically when those practices require teachers to manage and facilitate tasks requiring a higher cognitive load by students.

In summary, in order to create an environment where new, high quality mathematics practices can thrive, the role of the individual teacher, with their own beliefs, attitudes, and mathematical content knowledge, situated in a unique cultural context in a complex system, must be considered.

Purpose

The purpose of this study was to investigate one specific attempt to acknowledge the important role of the teacher: the use of a teacher-researcher partnership when developing an implementation plan for new mathematics practices. Recalling the need for improvement in mathematics education today, researchers purport that the role of the teacher in improving classroom instruction is critical. By focusing on the teacher's role to adapt the best possible knowledge available to the needs of his or her students, this work can contribute to a broader understanding about which types of reforms work in classrooms more generally.

As Vetter (2012) noted, little research "has examined teachers' change process to better understand what professional spaces foster teachers as they construct their own transformation" (p. 28). With the focus on the role of the teacher, and perhaps more importantly, the change or transformation teachers continue to go through as part of on-going learning, the possibility of research partnerships becomes one area that, through more research and understanding, could help to foster meaningful change in mathematics instruction. Recognizing this, more and more researchers are focusing on how to help teachers learn, grow, make decisions, and change all with the ultimate goal of the improvement of mathematics education. Spencer et al. (2012) recently identified three aspects of instructional decision making – "best available evidence, professional judgment, and client values and context" (p. 144) – but acknowledged these as theory-based only, with little supporting empirical evidence. They further suggested that investigating this theory is, of course, “best approached through collaborative relationships between invested researchers and practitioners” (p. 145). Identifying limited resources as a current reality in education, Penuel et al. (2011) called for more research on models that can develop change in different contexts, suggesting that partnerships play an important role in the future of student success.

One possible solution to address the needs of the individual teacher when planning for the implementation of new instructional strategies would be for an intimate relationship between researchers (planning new strategies based on research) and teachers to exist. Yet reality indicates that this is furthest from the truth. While it may seem useful that the practitioners implementing a change should have a pivotal role in designing that change, this is often not the case, as there is a well-known gap between researchers and practitioners. In their research on the implementation of reform-based practices, Leikin and Levav-Waynberg (2007) specifically identified the gap between theory and practice as one of the main reasons why changing instruction is so difficult. They even went so far as to suggest that change will be impossible to sustain unless communication between researchers and practitioners is developed. The researcher-practitioner gap exemplifies the absence of teacher contexts when planning models of instructional change. Closing this gap by nature acknowledges the importance of the role of the teacher when thinking about improved classroom instruction.

Research Questions

With the goal of improving the opportunities students have to receive a high quality mathematics education by implementing research-based practices into the classroom and framing teachers as a centerpiece of this work, the following research questions emerged:

a. How do mathematics teachers view their own participation in a teacher-researcher partnership?
b. How does the implementation of a new mathematics practice differ between teachers who participate in a teacher-researcher partnership and those who do not?
c. What features of a teacher-researcher partnership support the implementation of new practices in mathematics classrooms?

Importance of the Study

Currently, the Common Core State Standards (CCSS) mediate the discussion of how mathematics is taught in classrooms across most of the country (CCSSI, 2012). Taking direction from the earlier National Council of Teachers of Mathematics (NCTM) Standards, the CCSS for Mathematics (CCSSM) pose both content standards as well as mathematical practice standards in an attempt to mandate the types of problem solving skills, communication, and reasoning suggested by earlier reform efforts. Many researchers have shown that the NCTM-based reform practices significantly improve performance of all students (Boaler & Staples, 2008; Desimone, Smith, Baker, & Ueno, 2005; Hamilton et al., 2003; McKinney, Chappell, Berry, & Hickman, 2009; Silver & Stein, 1996). In individual cases, these practices have been shown to increase scores of all students and narrow the gap in scores between white students and African American and Latino/a students. Silver and Stein's (1996) research on the QUASAR project was one of the original examples of how a reform-based model showed significant achievement gains for all students while also narrowing the gap among the achievement of students of different races. More recently, Boaler and Staples (2008) found similar outcomes when examining three different schools; schools using NCTM-based methods had the best achievement outcomes for diverse student populations. Additionally, a review of NCTM's reform-based instructional practices came from McKinney, Chappell, Berry, and Hickman (2009). Their research indicated that many of the NCTM-defined reform-based practices are being used successfully in classrooms to "foster students' learning" (p. 282).

Many universities, non-profits, or for-profit companies are attempting to assist teachers in the implementation of these practices – most recently defined as those aligned with the CCSSM. Yet with no definitive evidence of a universally successful model of mathematics reform or of the sustainability of scaling up currently successful models of implementation (Borman, 2009; Confrey & Stohl, 2004), the importance of the individual teacher must be acknowledged. This study sought to understand the role a research partnership had in valuing the context of the individual teacher with the ultimate goal of bringing research-based practices into more classrooms.

Definition of Terms

Teacher-Researcher Partnership

A teacher-researcher partnership, also abbreviated in this paper as simply a research partnership, is a joint involvement between researchers and teachers to create new knowledge (Everett et al., 2007). Teachers can be "jointly" involved with research in one of three primary ways: as an active researcher, as a collaborator, or as a combination of both. Implementation research is an example of a combination of both, because it values the nuances of a classroom setting and teacher voices and makes the results accessible and applicable to other teachers, while also contributing to theoretical knowledge and innovative solutions (Ormel et al., 2012; Penuel et al., 2011). Ideal partnerships begin with a teacher-identified educational problem, use an iterative and collaborative model, apply relevant theoretical knowledge, and focus on creating a sustainable change (Penuel et al., 2011). Ultimately, a teacher-researcher partnership focuses on "engaging practitioners in the co-creation of new knowledge" (Ormel et al., 2012, p. 968), where the term practitioners in this paper specifically refers to teachers.

Research-Practice Gap

In many fields of study, a discrepancy between the knowledge and theory of researchers and the enacted work of practitioners exists. Spencer, Detrich, and Slocum (2012) specifically identified this gap as existing "between the methods that are best supported by systematic research and those that are most widely used" (p. 127). Known as the research-practice gap, this phenomenon has been documented within the field of education by many researchers (Burns & Ysseldyke, 2009; Chafouleas & Riley-Tillman, 2005; Everett, Luera, & Otto, 2007; Groth & Bergner, 2007; Lagemann, 2000; Malara & Zan, 2002; Richardson, 1990; Spencer, Detrich, & Slocum, 2012; Stein, Freel, Hanson, & Pacchiano, 2013).

Instructional Practices

Instructional practices is a generic term that refers to all methods and strategies used by a teacher during instruction. In attempt to identify the most effective instructional practices, the National Council of Teachers of Mathematics (NCTM) began a movement that "encouraged teachers to use instructional practices to promote the development of conceptual mathematical knowledge and skills" (Firmender, Gavin, & McCoach, 2014, p. 216).

Reform-Based Practices

Reform-based instructional practices in mathematics education are generally defined as practices originally based on the 1989 NCTM document *Curriculum and Evaluation Standards*. These methods typically involve problem solving, communication, reasoning skills, and mathematical connections. Literature since the year 2000 has continued to expand the definition of reform-based mathematics practices, yet the general consensus remains close to the NCTM-based reforms. Boaler (2002) specifically defined reform-based mathematics practices as "the idea that open-ended problems that encourage students to choose different methods, combine them, and discuss them with their peers would provide productive learning experiences" (p. 239). Firmender, Gavin, and McCoach (2014) claimed these practices "involve a shift of instructional focus toward engaging students in mathematical reasoning and problem solving, encouraging students' conceptual understanding, and developing classrooms as mathematical communities" (p. 215). McCaffery et al. (2001) characterized reform mathematics as "cooperative learning groups, inquiry-based activities, use of materials and manipulatives to promote meaningful representations of mathematical concepts, and open-ended assessment techniques" (p. 495). Similarly, Le et al. (2006) used the term *reform-oriented teaching* to describe "a collection of instructional practices that are designed to engage students as active participants in their own learning and to enhance the development of complex cognitive skills and processes" (p. iii). The themes of collaboration, discourse, and solving open-ended tasks appear repeatedly in additional definitions. The recent adoption of the CCSSM, including the Standards for Mathematical Practice, as well as statements by various national organizations in education indicate a shift in the understanding of desired mathematics instruction to include engaging, challenging, and in-depth analysis and investigation of content as key components of instructional practice (Firmender et al., 2014).

The idea of *reform* in education, however, is highly polarized, partially due to the political influences on reform. Additionally, colloquial usage of the term *reform* tends to be associated with specific, often market-driven reforms such as school choice and performance pay, among others (Scott, 2011). Reform in mathematics education is not immune to political influences, conflicting ideologies, and polarized supporters on all sides.

Research-Based Practices

With increased attention and controversy surrounding reform-based practices, researchers have conducted studies to examine the relationships between reform-based instructional practices and student achievement (Firmender et al., 2014). To the extent that positive outcomes have been found on student achievement, these practices are referred to as 'research-based practices.'

For the purpose of this paper, the term 'reform-based practices' will be used sparingly. When needed, the non-politicized idea of reform as 'a change to improve education,' with all of the complexities of education acknowledged, will be used in the remainder of this paper. Instead, the term 'instructional practices' will be used to indicate the instructional activities that exist within a mathematics classroom, and the term 'research-based practices' will be used to indicate instructional activities that have been supported by empirical research, often times including the aforementioned ‘reform-based practices’ which have a strong research base as well.

Summary

Understanding instructional change is a critical component of bringing high quality mathematics instruction to all students, which is the foundation of improving mathematics achievement across the country. With increased calls for improved achievement and equitable achievement in secondary mathematics, the need to reform mathematics education exists. Additionally, with high rates of proposed changes in current education policy and discussions, especially with the Common Core State Standard Initiative, the success of schools to meet the country’s growing demands relies on the ability of educators and researchers to come together. As policy makers and school leaders aim to make decisions to improve mathematics education, research on the importance of teachers’ roles and teachers’ beliefs must be considered. Although the research-practice divide has previously limited the ability of researchers and practitioners to fully benefit from each other’s work, the new era of high stakes accountability has provided an awareness of the inequities that exist in mathematics education. Addressing this problem successfully requires all instructional reforms to be aligned with current research.

Research has shown that the most effective changes to student achievement come from teacher-based measures, specifically instructional practices used in the classroom. Yet much of the information available on how instructional change can best be implemented is often overlooked. Even with no single answer as to the best strategy for reform in the mathematics classroom, research has shown that research partnerships can give teachers a voice in implementing change. When implementing instructional changes, teacher beliefs, attitudes, and contexts must be addressed. Therefore, researchers need to tailor their work towards the existing realities of classrooms, and school leaders need to respect the complicated process of attempting an instructional change. With mixed results of student success with reform-based mathematics, stakeholders in education must turn to the implementation process and the role of the teacher. Examining research-partnerships and their impact on teachers' practices is one way to begin to understand how student achievement can be sustained throughout the nation.

This study investigated the ability of a teacher-researcher partnership to impact the use of a specific high quality instructional practice in mathematics classrooms. In the literature review, I will first explore the nature of change in classroom practices, considering such factors as professional development, creation of knowledge, and teacher beliefs and attitudes before then examining the gap that exists between teacher and researcher perspectives when considering classroom change. Existing research on partnerships will be discussed, and a theoretical framework based on teacher inquiry will be presented as a lens to consider the research question of the ability of a teacher-researcher partnership to impact classroom change. The methodology section will describe how I used an Interpretative Phenomenological Analysis to review survey, interview, and observation data from a secondary source involved in a teacher-researcher partnership. The results will be shared, and I will conclude with a discussion of the results, implications, and directions for future research.

CHAPTER 2

REVIEW OF THE LITERATURE

Implementation of New Instructional Practices

Despite a solid foundation of research supporting reform-based practices as important factors in increasing mathematics achievement for all students, these types of practices are not being implemented universally (Boaler & Staples, 2008; Gregoire, 2003; Hiebert & Stigler, 2000; Huffman, Thomas, & Lawrenz, 2008; Leikin & Levav-Waynberg, 2007; McKinney et al., 2009). A 1999 video study as part of the Third International Mathematics and Science Study (TIMSS) indicated that while teachers believed they were implementing problem-solving based practices, observations of classrooms did not support such statements. In attempting to further explore the teacher's role in classroom change, Hiebert and Stigler (2000) found that teachers' attempts to implement new practices were superficial at best. For example, when a suggested practice called for meaningful interaction and discussion among students, teachers might simply place students in groups without meaningful tasks assigned. Ding, Li, Piccolo, and Kulm (2007) confirmed similar results; in a study on cooperative learning, they found that teachers would put students in small groups without focusing on the goal of cooperative learning – to develop students' mathematical thinking independent of the teacher.

Similarly, Leikin and Levav-Waynberg (2007) observed that reform practices were not happening, noting that teachers found this style of teaching difficult. Although their research was conducted outside of the United States (and therefore under a different political context), they investigated recommendations for solving problems in multiple ways, a strategy also suggested by mathematics educators in the United States. With a specific focus on urban, high-poverty schools, McKinney et al. (2009) also researched both which and to what extent research-based instructional practices were used in elementary school mathematics classrooms. Their results indicated that while many of the NCTM defined reform-based practices are being used successfully in classrooms, many of these practices are also *not* being used universally, and traditional instruction still permeates most classroom instruction today. Gregoire (2003) documented many more such cases and continued her work, published under the name Gill in 2012. Gill and Boote (2012) sought to counter the narrative of unsuccessful implementations of reform-based mathematics by analyzing the practices of someone who they thought to be an educator who had embraced a problem-solving classroom philosophy, yet observations proved otherwise. Researchers continue to search for better ways to understand how to implement practices that have been shown to be beneficial to mathematics learning given complex individual and collective circumstance.

In order to create a system in which research-based instructional practices can be implemented successfully, researchers and practitioners alike need to understand the variety of contexts that influence teachers' abilities to enact the needed changes in their classrooms. Factors affecting the implementation of new practices include teacher beliefs, attitudes, and their cultural context and teacher learning and professional development.

Teacher Beliefs and Attitudes

To understand the role of the teacher in implementing new practices, one must also understand the importance of their belief system. Forman, Smallwood, and Nagle (2005) critiqued a common assumption that researchers may have when presenting new innovations for classrooms thinking that practitioners will use the information after they learn about it. What Forman et al. (2005) pointed out was that educators "do not make professional decisions based solely on what they read or hear at a presentation and do not act in isolation" (p. 572). Instead, their beliefs and attitudes play a large role in the decisions to implement.

Ernest (1989) laid the groundwork for understanding the importance of teacher knowledge, belief, and attitudes towards new practices when confronting instructional change. Many researchers have found that teachers' beliefs, specifically, closely influence their choices for instructional practice (Handal & Herrington, 2003). In attempting to understand more about individual teachers' experiences and attitudes towards reform-based practices, Rogers, Cross, Gresalfi, Trauth-Nare, and Buck (2011) interviewed three teachers who were using project-based learning and discovered that teacher orientation, or the beliefs behind teachers' choices, was critical to the amount of success they had while implementing the new practice. McKenzie, Skrla, Scheurich, Rice, and Hawes (2011) corroborated the findings of Rogers et al. (2011) with their examination of three urban schools, concluding that teacher orientation has a direct impact on the success of new practices.

In examining a case study, Gregoire (2003) proposed a model to understand why teachers who support new practices aren't able to implement them in the classroom: pre-existing beliefs serve as limitations. "Understanding how teachers' beliefs relate to their practice as well as to student outcomes may be the missing link between calls for school reform and teachers' implementation of that reform" (Gregoire, 2003, p. 149). Handal and Herrington (2003) similarly suggested that the failure of many past implementation efforts could be attributed to a discrepancy between the expectations of the curriculum creators and the beliefs of the teachers. They went on to warn that not only does the success or failure of an individual implementation effort depend on the attempt made to address teacher belief systems, but that curriculum mismatched with teacher belief systems can worsen teacher morale and their motivation towards future implementation efforts. Confrey, Castro-Filho, and Wilhelm (2000) also documented that implementation can be shallow if new strategies don't change instruction at its core by addressing teachers' beliefs. In an attempt to describe successful implementation, Forman et al. (2005) identified two factors that affect implementation: school support for the implementation and beliefs that the implementation fits with individuals' values and will ultimately prove helpful. "Staff members who perceive the innovation to be consistent with their values are more likely to be committed and enthusiastic in their innovation use" (Forman et al., 2005, p. 570).

It is important to note that a change of practices does not necessarily lead to a change in beliefs (Gregoire, 2003), and that beliefs can persist even after many hours of professional training (Gill & Boote, 2012). The tension between reform policy and teacher beliefs can also lead to increased resistance from teachers (Confrey et al., 2000). These challenges become increasingly alarming with the realization that "without significant changes in subject-matter beliefs, maintaining radically new ways of instruction is almost impossible" (Gregoire, 2003, p. 149).

Analysis of individual beliefs neglects the social structure under which beliefs are created. In Leikin and Levav-Waynberg's (2007) study of the introduction of solving problems using multiple strategies in the classroom, they understood that teachers' abilities to interact with the new practices were limited by beliefs that were situated within their social interactions. Another study, a qualitative ethnographic study with the goal of understanding the implementation of classroom practices, focused on the importance of classroom culture (Gill & Boote, 2012). Gill and Boote (2012) found that three aspects of culture – individual (beliefs and attitudes), interactional (discourse), and collective (social norms) – act upon a teacher's decision making process, demonstrating that the alignment of beliefs to implementation practices is much more complex than earlier researchers described.

Gill and Boote'e (2012) analysis served as an important narrative to understand why teachers who value new instructional practices might not be implementing them with the fidelity that they self-report. Claiming that the teacher in the study used instructional practices that were guided by the collective cultural importance of procedural mathematics, they explained that she did not just misunderstand the strategies or disagree with the important values behind the strategies, (Gill & Boote, 2012, p. 19) as a simpler analysis of the challenges of implementation might posit. Instead, they claimed her "persistent use of procedural mathematics is neither aberrant, nor naïve, nor irrational; it is an entirely sensible way of behaving when understood within the culture of schooling" (Gill & Boote, 2012, p. 35). Using the collective view of classroom culture, Gill and Boote distinguished themselves from other researchers in trying to understand how beliefs and attitude facilitate or prevent the implementation of new mathematics practices by honoring the actions of teachers as meaningful and deliberate and acknowledging that no matter how much researchers discuss best practice in education, it is the teacher "who really has the power to police the boundaries of practice in her classroom" (Gill & Boote, 2012, p. 36). They continued:

> What seems clear from this analysis of [the teacher's] mathematics classroom culture is that many of the suggestions to improve the teaching of mathematics seem at best naïve. The individual focus of most research leads us to believe that reforming mathematics education is simply a matter of encouraging teachers to change their beliefs and values, leading to frustration when we find that those beliefs and values are only likely to change in the direction of procedural mathematics. (p. 37)…

With this information, Gill and Boote (2012) concluded that it is of critical importance to recognize the complexity of the factors that ultimately influence teachers' daily decisions, including those that support new instructional practices. Teachers' beliefs and attitudes do impact their ability to implement new practices, but these beliefs and attitudes are situated within larger structures of culture that cannot be ignored.

Professional Development

Teacher learning, commonly occurring through professional development, can affect both the implementation of a new practice as well as teachers' attitudes and beliefs about students and mathematics. In his seminal work on professional development, Guskey (1986) suggested that professional development is "a systematic attempt to bring about change" (p. 5). Akiba (2012), however, differentiated between activities aimed at professional learning – "intentional activities to gain new knowledge about teaching and student learning" (p. 3) – and actual professional learning – "cognitive changes in teachers' knowledge and beliefs" (p. 3) as a reminder that actual cognitive changes are not guaranteed simply by attending a learning activity, nor are learning activities a prerequisite for cognitive changes to occur. Similarly, the definition of professional development becomes fluid, with some researchers characterizing professional development as formal, structured programs aimed at specifically targeted outcomes (Akiba, 2012; Heck, Banilower, Weiss, & Rosenberg, 2008) and others counting informal professional learning, such as teacher collaboration, action research, exploring individual professional interests, and peer observations and feedback as professional development (Conway, Edgar, Hansen, & Palmer, 2014; Guskey, 1986; Lom & Sullenger, 2011; Lopez-Pastor, Monjas, & Manrique, 2011; Parise & Spillane, 2010). In this paper, both definitions will be explored.

DeSimone (2009) suggested a theoretical trajectory for the impact of professional learning on classroom outcomes: 1) teachers attend meaningful professional development; 2) teachers increase their skill sets and knowledge; 3) teachers change their beliefs and attitudes; 4) these changes are applied to classroom content and instruction; and 5) student achievement increases. This model differs significantly from Guskey's (1986) seminal model of change, in which he emphasized that after professional development, instructional practices change first, followed by a change in student achievement, and a change in beliefs and attitudes only coming after teachers have observed student outcomes. Opfer and Pedder (2011), as a critique of the linear process for change suggested by the former two models, merged these two models to suggest an iterative nature of changing instructional practices and beliefs: "Changes in beliefs lead to changes in practice that bring changes in student learning that bring further change in practice that result in additional changes in belief and so on" (p. 395). In this model, the change process can begin at any point in the cycle.

The extent to which any of these trajectories play out in the real world is an area of deep study for researchers, with mixed results. Within formalized structures of professional development, researchers have attempted to identify characteristics of successful programs. Guskey (1986) originally theorized that regular feedback and intentional support and follow-up would be critical components of professional development. Twenty-three years later, however, Guskey (2009) found a significant gap between his beliefs and actual evidence of successful professional development. Many researchers may claim to know what factors influence successful professional development, yet when studies are rigorously reviewed, few consistent results emerge. A thorough literature review of 643 studies, for example, only found 2 studies with positive effects of professional development specifically on students' mathematics achievement (Gersten, Taylor, Keys, Rolfhus & Newman-Gonchar, 2014). The findings indicated that intense instruction in mathematics content as professional development, in conjunction with universities, and with planned follow up and teacher-led lesson studies, positively impacted student outcomes (Gersten et al., 2014). Other basic claims include that professional development is most successful when it is sustained and continuous (Akiba, 2012; Heck et al., 2008; Taton, 2015), is consistent with classroom and school expectations (Akiba, 2012; Heck et al., 2008; Parise & Spillane, 2010), encourages collaboration (Akiba, 2012; Parise & Spillane, 2010; Taton, 2015), contains active learning experiences (Parise & Spillane, 2010; Taton, 2015) and is content focused (Heck et al., 2008; Parise & Spillane, 2010). Also significant are the types of professional development that specifically have no effect on changes to classroom practices. These include graduate course work and isolated workshops (Parise & Spillane, 2010).

One longitudinal study did find positive results of mathematics professional development on both teacher attitudes and practices. As a 7-year study, these findings came from nearly 50 National Science Foundation (NSF) projects on professional development, teacher attitudes, and mathematics instructional practices (Heck et al., 2008). The researchers found a positive relationship between the professional development program and improved attitudes towards standards, content, and instructional practice as well as finding that the effect increased as participation increased. Of particular note, the study found a heightened importance on relating the professional learning to such district contexts as specific learning goals, policies, and vision. Additionally, Heck et al. (2008) found a correlation between teachers' views of principals' support of professional development initiatives and a change in teachers' attitudes and practices, suggesting that both professional development and school context are factors ultimately affecting the amount of professional learning that occurs.

The interaction of school context with professional development (Akiba, 2012; Guskey, 2009) and multiple confounding factors (Guskey, 2009) can make identifying successful characteristics even more challenging. Yet instead of seeing these realistic factors as a deficit to professional development research, they could be viewed as factors around which to differentiate and personalize development for specific groups of teachers as Guskey (2009) reminded us that no single strategy or professional development approach is successful in all situations. Opfer & Pedder (2011) extended this exertion to discern why some teachers attend professional development that models previously researched "effective" characteristics yet gain no benefit, while others continue to learn from professional development sessions that do not exhibit these previously identified characteristics. Suggesting the misinformed linear nature of change again as the problem behind the inability to identify effective characteristics of professional development, they conclude that any analysis or theory of professional development must include a complex model of teaching, learning, and the environments in which these occur, and that it should be thought of as a "system," and not as an "event." This complex model proposed by Opfer and Pedder (2011) included acknowledging that teachers' experiences with professional development result from the combination of "instructional practices, pedagogical beliefs, prior knowledge, and past experiences" (p. 393). Perceived support from school administrators, which may also be affected by the "interaction of collective practices and beliefs about learning" (p. 393), also plays a role in the ultimate success or failure of professional development, and it is only when all of these factors are considered together that the change afforded by professional development can begin to be understood.

Informal Professional Development

Recalling Guskey's (1986) view that professional development can be thought of more broadly as "a systematic attempt to bring about change" (p. 5), more informal methods of professional learning can be examined. While the most common types of mathematics professional development are formal, structured programs and teacher collaboration, the time spent in these activities remains limited (less than 60 hours per year combined, according to Akiba (2012)). Parise and Spillane (2010) acknowledged that not only does learning come both from formal professional development as well as informal collaboration, but that both have positive effects on teacher change in mathematics classrooms. In their survey study of teachers at 30 elementary schools, they found evidence from self-reported data that collaborative conversations had the most impact on change in the mathematics classroom.

Another form of informal professional development, specific to the field of mathematics education, is a Math Teachers' Circle. Taton (2015) argued that to help their students grow as mathematical thinkers, teachers need opportunities to increase their abilities as mathematical thinkers themselves. The Math Teachers' Circle was designed to give teachers the opportunity to practice mathematics as a mathematician might as well as to contribute to the production of mathematical knowledge. Results from a one-year study of a Math Teachers' Circle indicated increased confidence with and use of high quality mathematics practices (Taton, 2015).

When considering the informal definition of professional development to include any "process in which teacher learning occurs" (Lom & Sullenger, 2011, p. 57), the act of research itself should be considered an influential agent of change. Conway et al. (2014) pointed out that participating in research is a significant form of professional development particularly because of the connection between personal experience and theory.

Based on interview data from teacher participants in a collaborative after-school science research project, all agreed that their experience constituted professional development "as rigorous as any other" (Lom & Sullenger, 2011, p. 67). The researchers found five categories that described the ways that teachers were engaging in professional learning: "interacting with others, participation in curriculum development, learning as professional development, transfer to the classroom, and becoming known" (p. 61) with professional interactions proving to have the most impact. The cooperative nature of this research project meant that teachers were involved with the development and implementation of the research, making them active learners involved with professional reflection (Lom & Sullenger, 2011).

Another set of researchers studied the effect of action research on teachers' professional learning over the course of 15 years (Lopez-Pastor et al., 2011). A university-sponsored workgroup spent time researching curricular materials and instructional practices to promote reflection and learning among teachers. Results showed improved instructional practices through the collaborative interactions and a bridge between theory and practice throughout the research processes (Lopez-Pastor et al., 2011).

Ultimately, as the nature of education is changing, so must the nature of professional development. Expanding beyond the traditional notion of formalized and structured professional learning for teachers, educators can learn and grow through many informal opportunities, including participating in research. To this end, Lom and Sullenger (2011) noted that teachers should be much more involved in the process of knowledge creation and dissemination. Similarly, Taton (2015) suggested, "professional learning experiences need to be more readily integrated with teachers' out-of-school intellectual and social lives" (p. 9). Because so little research indicates positive impacts of traditional professional development on instructional change, informal and research-based professional development may be a key catalyst to improving educational outcomes.

Theories of Change

To understand how classroom change – the ultimate goal to improve mathematics outcomes – actually occurs, the interaction between teachers' beliefs and professional learning experiences needs to be examined. While this study does not include a specific measure of change, the potential for teacher-researcher partnership to impact instructional practices could imply that a larger change process could be facilitated through collaborative work.

Some researchers or policy makers might use the lack of agreement on key characteristics of professional development to conclude that any attempt to implement new practices would need to include provisions to change teachers' beliefs about mathematics education first so that the new instructional practices could be successful. However, the ability to change teachers' actual beliefs is widely acknowledged to be challenging if not impossible. With this information, Guskey (2002) and Çetinkaya (2012) are two of many researchers who have proposed alternate models. Based on an understanding of where change comes from, what motivates teachers to make changes, and the current theories of instructional change, they believed reform-based practices can successfully be implemented in classrooms by addressing teachers' concerns about the change with nuanced guidance, targeted professional development, and differentiated support. In her case study, Vetter (2012) found that an individual teacher was able to change her beliefs about her practices through a guided process.

Other research has shown that some teachers may be more likely to change than others. Carol Dweck (2010), famous for her fixed mind-set and growth mind-set theories on student intelligence, asserted that the same theories of mind-set apply to teachers as well. If teachers have a fixed mind-set, they believe they cannot influence student intellectual capabilities, but if teachers have a growth mind-set, they believe their actions could positively influence students' capabilities. Dweck's research has shown that teachers who hold a growth mind-set close achievement gaps in student performance faster than those who hold a fixed mind-set. She has also suggested that teachers with growth mind-sets are more open to professional learning for themselves. Therefore, in reviewing the importance of teacher beliefs towards change, Dweck's research on mind-sets might provide insight into which teachers are able to create lasting change in their classrooms – those who exhibit growth mind-sets – and those that are not.

As an additional perspective of classroom change, Gregoire (2003) refuted five other models of conceptual change in favor of Cognitive–Affective Model of Conceptual Change (CAMCC). This model included eight stages, starting with teachers learning about an upcoming change and completing a self-assessment of their views towards the change. Interestingly, in this model, if a teacher viewed the change too positively, he or she might not be able to truly engage with the discomfort of addressing a change, resulting in either no change or a superficial change at best. The next step was the stress appraisal, where the suggested change is measured as motivating or threatening to a teacher, depending on his or her self-efficacy. Finally, based on self-analysis of ability, including having the time, knowledge, and resources available to engage with the change, a teacher decided to either accept or decline the challenge of implementing the new practice. If a teacher accepted the challenge, he or she set goals and finally reached the last step of the CAMCC process, where thoughtfully engaging with the implementation could lead to an acceptance of the new strategies. According to Gregoire (2003), "a major tenet of this model is that significant, lasting belief change cannot occur without teachers' systematically processing reform messages" (p. 168). Anything less, and a teacher may only implement changes at a superficial level, without a deep commitment to the change. This could explain why other researchers have found so few authentic cases of newly implemented research-based practices (Boaler & Staples, 2008; Gregoire, 2003; Hiebert & Stigler, 2000; Huffman et al., 2008; Leikin & Levav-Waynberg, 2007; McKinney et al., 2009).

"An additional implication of the CAMCC for facilitating belief change in teachers is that teacher educators, policymakers, and researchers should recognize that it is not enough to increase teachers' motivation to change their beliefs about a subject. Rather, they should examine ways to increase teachers' ability to reflect upon and successfully implement advocated reforms" (Gregoire, 2003, p. 172). The CAMCC model suggested that it is the individual processing teachers go through when addressing changes in their classrooms that can actually cause successful implementation, and any educational leadership structure interested in helping to make these changes must find ways to assist teachers with this processing. Gregoire (2003) also suggested that one way to assist teachers with this processing is to focus on their efficacy. Because their belief in their own abilities has a significant impact on their self-assessments, focusing on improving teacher efficacy can help improve implementation success based on the CAMCC model.

Even with extensive research on the external conditions under which instructional change is more likely to occur, many attempts to infuse instruction with research-based practices meet with failure. Instead of mandating instructional changes or trying to coerce changes in belief, the most successful research-based change methodologies include helping teachers to have a growth mindset about their students and having confidence in their own abilities. These factors, coupled with assisted strategic processing of change, can help to ensure students are receiving the best research-based instructional strategies in the classroom, especially when the change practices vary from previously common traditional teaching styles. Ultimately, all aspects of instructional change will be mediated through a teacher. Teachers need to grapple with the change and feel empowered because of their own ability and autonomy to take action. Knowing this, suggestions for change or reform of mathematics instruction must include the teacher as an active participant.

The Research-Practice Gap

Misalignment between policies to implement new instructional practices and teachers' abilities to enact change in the classroom may come from not providing adequate opportunities for teacher input on reform, not giving teachers the opportunities to grapple with the changes, or not respecting the teacher's role in the actual implementation process. With all of these factors, the underlying cause is the same: a lack of communication among various stakeholders in mathematics education reform. Despite the best efforts of some researchers and teachers, this communication gap manifests itself as a well-documented research-practice gap, with consequences being that interventions are rarely designed with teachers at the forefront.

Educational research serves three goals: improve learners' understanding; create new knowledge, and improve pedagogy (Ormel et al., 2012). In order to meet any of these goals, research and practice have to be linked. Some policy makers understood the importance of this connection and advocated for evidence-based practices through the NCLB Act of 2001 and the Individuals with Disabilities Education Act (IDEA) of 2004, which made the use of research or evidence to inform decision-making processes law (Spencer et al., 2012). While enforcement of the law may be difficult, Spencer et al. (2012) suggested that the awareness of research when making important decisions that may involve many complex interactions is one way to work towards making the best decision possible, while accounting for the individuality of a specific school or classroom at the same time. Evidence-based or research-based decisions can have far-reaching impacts on the success of a model used in attempt to improve instruction at a school. Spencer et al. (2012) stated:

> The evidence-based practice model asserts that the best available evidence should be one of the three main influences on educational decision-making. The term *best available evidence* implies that there is a range of evidence and that educators should select the best of what is available – although seemingly simple, this concept is powerful and has far reaching implications for educational practice. (p. 133)

Despite the acknowledgement of the importance of evidence and research to practice, very little research is used to inform practice (Everett, Luera, & Otto, 2007; Spencer et al., 2012), and very little practice is used to inform research (Skovsmose, 2006; Spencer et al., 2012). This phenomenon is known as the research-practice gap and while not new, neither researchers nor practitioners have adequately found ways to work together to bridge the gap (Chafouleas & Riley-Tillman, 2005).

With the goal of mathematics education reform to improve educational outcomes, the research-practice gap is concerning. Theory or research might suggest strategies to reach this goal, but if these same strategies are not implemented in the classroom, the goal of improved outcomes and achievement will not be met. True reform, ergo improving educational outcomes, is not to simply offer the use of a set of standards or curriculum; it can only occur when researchers, teachers, and other stakeholders work together to implement research-based practices and curriculum towards the common goal of increased student achievement (Penuel et al., 2011). In mathematics education, an area that has seen almost two centuries of debate about the nature of mathematics, student achievement might best be served by focusing less on out-of-context theories and more on the relationship between teachers and the research.

The detriment of the research-practice gap is that it implies knowledge of well-researched practices does not reach actual classrooms and that the realities of the classroom are not always considered in research. Oft-cited arguments from teachers claim that research isn't applicable in individual, unique settings. Researchers, on the other hand, may find the uncontrollable situations within a classroom challenging when dealing with the validity of research (Chafouleas & Riley-Tillman, 2005). Dissemination issues can feed the research-practice gap (another component of the larger communication issues), as can the concern that the topics that researchers and teachers may choose as the important topics to focus on are not aligned (Chafouleas & Riley-Tillman, 2005). In some areas, research has shown that some mathematics education practices have very little effect on student achievement, yet are still used consistently in classrooms; however, some practices persist in classrooms even after data has shown them to be clearly ineffective (Burns & Ysseldyke, 2009). Statistically, Burns and Ysseldyke (2009) documented the research-practice gap in a study of the frequency of research-based practices used by 174 special education teachers and 333 school psychologists. They found no correlation between effect size of a research-based technique and teacher reported use; that is, techniques that were found to be highly effective may have either been widely used or not-widely used, and techniques that were found to be ineffective were sometimes used and sometimes not used as well. Star et al. (2015) similarly found a lack of implementation of research-based practices in the classroom. Specifically investigating the implementation of comparing and contrasting examples in algebra 1 classrooms, Star et al. (2015) found that despite results demonstrating higher achievement for students who were given opportunities to interact with these practices, the practices were not widely used among teachers in the study, even with agreed upon parameters.

The research-practice gap is not unique to education, and the impact of the generalized gap was described by Spencer et al. (2012) to illustrate "consumers are not receiving services that are based on the best research evidence that exists and therefore may suffer from poorer outcomes…" (p. 128). When consumers are students in the case of education, this statement discouragingly implies that the practices research shows to improve achievement are not frequently used. In this way, the research-practice gap has troublesome implications for the improvement of education and especially for the equity of education. In the world of policy mandates and instructional reform, these gaps manifest as failed reform models, frustrated teachers, isolated researchers, and ultimately, less prepared students.

Despite a push by national educational organizations to bridge the gap between researched and enacted practices, "it is commonly accepted that little research actually makes its way into classrooms and teachers' everyday practices" (Everett et al., 2007, p. 1). The existence of a research-practice gap has been documented in all areas of education, including special education (Burns & Ysseldyke, 2009), early childhood education (Stein et al., 2013), school psychology (Forman et al., 2005) and especially mathematics education (Groth & Bergner, 2007; Lagemann, 2000; Malara & Zan, 2002; Richardson, 1990).

Causes of the Research-Practice Gap

Many researchers and education scholars have studied and hypothesized the causes of the gap between what researchers know and what teachers do. Robert Slavin (2013), director of the Center for Research and Reform in Education at Johns Hopkins University's School of Education, suggested four reasons for the fact that research-based reforms have not impacted student achievement, even after many attempts: 1) not enough "rigorous evaluations" of potential interventions exist; 2) an inability to circulate results of researched programs; 3) no incentives for schools or districts to implement research-based practices; and 4) a lack of support when implementing research-based practices. His narrative provided critical insight into the causes of the research-practice gap and added to the understanding of why the gap persists. Other researchers have identified additional reasons for the gap between researchers and practitioners, agreeing with Slavin on the lack of access and support. The additional reasons included a concern with the predominant view of the exchange of information from a top-down approach and the lack of communication between researchers and practitioners (Burns & Ysseldyke, 2009;

Everett et al., 2007; Groth & Bergner, 2007; Leikin & Levav-Waynberg, 2007; Stein et al., 2013).

Slavin (2013) suggested both that teachers may not have easy access to the results of researched programs and that they might not receive enough support in implementing new programs; other researchers agree. Everett et al. (2007) documented a lack of access to research publications, and Burns and Ysseldyke (2009) even suggested that teachers prefer receiving information informally as opposed to reading research journals. Even if teachers want to use a new research-based practice, they may receive little support, both in terms of physical resources and pedagogical respect. Leikin and Levav-Waynberg (2007) noted in their research that sometimes teachers hit barriers in attempting to implement reform-oriented mathematics practices when their belief in the practices is not matched by their administration.

Extending beyond Slavin's (2013) conclusions about the research-practice gap, other researchers have mentioned the lack of communication between researchers and practitioners as contributing heavily to the gap in research and practice. When practitioners read or are exposed to mathematics education research, they report critical views on this work, citing such reasons as not having specific guidelines as to how to carry out the research in a classroom setting, not addressing actual classroom needs, or not providing any insightful information beyond what teachers already consider good teaching (Everett et al., 2007; Groth & Bergner, 2007). Conversely, researchers may have the opinion that teachers are not open to new ideas, are slow to change, or do not understand how to accurately interpret and apply research (Spencer et al., 2012).

Forman et al. (2005) described two extreme approaches of attempting to link research and practice, one being the "publish, admonish, and hope approach" (p. 569) in which researchers may attempt to enact change by publishing their research, speaking forcefully about it, and hoping teachers will heed their advice. The other extreme attempt at change could occur if an educational leader reads valuable research, and then attempts to revamp an entire organizational plan based on this research. On this continuum of linking research and practice, the extremes do not respect the knowledge and experience of teachers as well as organizational change processes; the most likely solution will be somewhere in between (Forman et al., 2005). Ultimately, when critical information is not exchanged between groups, this lack of communication affects the ability of educators to carry out the ultimate goal: implementing instructional practices that improve student achievement.

A lack of exchange of ideas and information related to perspectives on student learning serves as an additional reason the research-practice gap exists (Ormel et al., 2012). While many outside of the field of education may have a tendency to look upon the research to practice pipeline as a top-down chain with researchers providing information to practitioners, in reality, knowledge transfer should go both ways. Many researchers may act under the guiding question of how research can better inform teacher practice. Skovsmose (2006), however, shifted the dialogue, suggesting that how practice can influence research is an equally valid pursuit. Arbaugh et al. (2010) concurred, noting that researchers and practitioners can both learn from and advance the work of each other. A 2012 position statement from NCTM claimed that researchers and practitioners must work together, highlighting that "findings or interpretative insights must meet the needs of both the research and practitioners' communities to provide a principled basis for understanding students' and teachers' mathematical experiences, making decisions about policies, and knowing the impact of programs on mathematics teaching and learning" (p. 1).

Yet the tendency for researchers to remain isolated from the real world of practitioners (Everett et al., 2007) remains prevalent, just as Zeichner noted in his 1999 publication that the higher the status of a professor at a research university, the lower amount of involvement with teachers and students. Because of this tendency, the critical information about teachers' lived experiences with student learning is often left out of research considerations, contributing to the effect that teachers see this work as impractical for their daily use.

While researchers may contribute uniquely to the research-practice gap by distancing themselves from practical situations, so do teachers contribute by a tendency to hang on to outdated techniques. Research has shown that the well-known adage proves true: teachers are more likely to teach the way they were taught (Everett et al., 2007). Whether this comes from the effect of environment on knowledge development (Leikin & Levav-Waynberg, 2007) or from the strictly observational status every teacher has had as a student of at least 12 years (Everett et al., 2007), the tendency to cling to beliefs and attitudes that have been experienced in the past remains.

With the exact causes of any large phenomenon nearly impossible to isolate, it is clear that both researchers and teachers are affected by the gap; it gets in between the ability to share the knowledge and expertise related to successful outcomes in each field. However one chooses to approach the divide, it is clear that the relationship between research and practice is dynamic, ever changing, and critical to the future of mathematics education reform.

Possible Research-Practice Gap Solutions

Thinking about the consequences created by the research-practice gap, namely that students might not be receiving the best possible education or that researchers are not addressing issues with teacher implementation in mind, it is critical that steps are taken in attempt to close the gap and further educational outcomes. With a solution of engaging teachers in the process of using evidence-based practices or research-based strategies, change can occur in classrooms such that students receive the best educational practices for their unique circumstances (Byman et al., 2009; Everett et al., 2007; Spencer et al., 2012). Even this idea, however, can take many forms. Byman et al. (2009) suggested that one way to bridge the research-practice gap was to implement more research in pre-service teacher education curriculum. After an initial trial, students seemed to appreciate that approach, but no longitudinal studies were completed to test for lasting impacts once teachers were in the field. Another attempt to involve pre-service teachers in action research found that pre-service teachers were able to increase the utilization of knowledge from education research in their own practice, but they did not see their own actions as contributing to the research-base in the field of education (Everett et al., 2007).

Most attempts to incorporate researcher and practitioner expertise stem from work with in-service teachers. Everett et al. (2007) summed up the goal of bridging the gap, stating “teachers need to be jointly involved with researchers in creating knowledge rather than expecting teachers to transfer knowledge from ‘distant’ research studies to their own teaching practices” (p. 2). Teachers can be “jointly” involved with research in one of three primary ways: as an active researcher, as a collaborator, or as a combination of both.

Action Research

While teachers have been informally doing action research for many years, the acknowledgement of the teacher-as-researcher in academic literature first came from Lytle and Cochran-Smith in 1992. They have continued to work together at the center of the teacher-researcher field since then, adding much knowledge to the field of action research and suggesting that action research could be a turning point for educational change (Cochran-Smith & Lytle, 1998). Action research can be defined as small-scale research studies done by a practitioner that explore ideas situated within an understanding of already existing literature within the confines of a single classroom or school, with the goal of sharing the benefits found for children's learning (Evans, Lomax, & Morgan, 2000; Vetter, 2012). Action research, when implemented with intention, can specifically bridge the theory versus practice divide (Lopez-Pastor et al., 2011). Action research aims to give teachers a voice, allowing them to ask and explore questions meaningful to their own practices and their own students (Evans et al., 2000). While small nuances in definitions may exist, action research may also be known as teacher-researcher work, practitioner researcher, or practitioner inquiry. Similar to Cochran-Smith and Lytle's (1998) findings, action research has been found to create changes in the classroom, specifically when teachers get together in groups to discuss their research and findings (Vetter, 2012). Vetter (2012) cited such changes as "professional confidence, awareness of classroom events, dispositions towards reflection, broadened views of teaching, teacher beliefs about themselves, their roles as teachers, and attitudes towards students" as some of the benefits coming from action research (p. 32). Other researchers have found better knowledge gains about how teachers teach and how students learn (Evans et al., 2000) and the development of curricula that is meaningful to an individual school (Nonis, 2008).

Despite the benefits found with action research, university researchers often ignore it, possibly because it differs from previously held expectations of academic research as being generalizable and experimental or quasi-experimental by design (Evans et al., 2000). Instead, it attempts to present a new framework for education research as being transferable, such that ideas that have been tried in one situation may be learned from and adapted in another situation. Because of this different approach to research and knowledge growth in the field of education, action research is both difficult for academic researchers to accept (Chafouleas & Riley-Tillman, 2005) yet also poised to impact schools and classroom instruction at a larger scale. Because of this dichotomy, challenges still exist in implementing action research. Specifically, time and resources are the primary barriers for teachers to implement action research well (Nonis, 2008). However, outside support, from a university for example, is one way teachers have identified as being able to overcome these barriers.

Collaboration Research

Collaboration as a general term means two or more groups working together, but in the field of education research, it generally refers to the partnership of a school or district with a university or other research-based institution. Both Nur (1983) and Schuck (2013) agreed that the essence of collaboration goes beyond simply working together and instead entails strategic identification of a problem, a unified commitment to the project, and action steps to research or solve the problem, all of which are agreed upon by all parties involved. Schuck (2013) also emphasized the importance of leadership coming from both parties. Many researchers have espoused the benefits of such partnerships, citing mutual learning for all who are involved (Schuck, 2013), innovative results and teacher motivation (Baumfield & Butterworth, 2007), and practical and relevant inquiry (Smith, 2000). Additionally, collaborations are an effective use of resources, as they expand on the strengths of each party involved, and are generally welcomed by teachers (Baumfield & Butterworth, 2007; Nur, 1983). Collaborations can help researchers remember the contexts of teaching that are critical to teachers every day (Chafouleas & Riley-Tillman, 2005). Researchers can attend to questions that are meaningful to teachers, and teachers can learn to use research as part of their understanding of best practices in the classroom (Chafouleas & Riley-Tillman, 2005).

As one example of a successful collaboration described by Cooper (2007), the Minority Student Achievement Network (MSAN), a collection of high-achieving districts with persistent achievement gaps among students of different races and socio-economic backgrounds, had initial goals to close achievement gaps. This network of school districts quickly found that closing the research-practice gap was a key component to their success. By engaging teachers, teacher-leaders, and administrators collaboratively with researchers around a central problem identified by the teachers – in this case, the different achievement scores among students of different races – MSAN districts collaborated on solutions based in current research in partnership with universities. Going beyond simply learning from research, however, the MSAN districts recognized the importance of participating in research by collecting data, evaluating programs, and sharing successes (Cooper, 2007). By doing so, a partnership was created such that knowledge transfer could go both ways – teachers as researchers and learners and university professors as researchers and learners.

Compared to a simply passive use of research-based ideas, active and ongoing partnerships utilize data from schools and are then able to apply the conclusions to their specific programs. In the case of an early childhood education program at a Chicago elementary school, leaders partnered with local evaluation experts. Data was collected from the elementary school and processed to inform the program as to how to best meet the needs of the students (Stein et al., 2013). This model led to innovative thinking and practices for the program leadership. Another successful collaboration between schools and universities in the United Kingdom was based on a similar idea of knowledge transfer: instead of assuming that the university has access to exclusive knowledge, their model capitalized on the knowledge and expertise that already existed among teachers (Baumfield & Butterworth, 2007). Hiebert, Gallimore, and Stigler (2002) similarly valued the knowledge of practitioners, suggesting that "archived research knowledge has had little effect on the improvement of practice" (p. 3) and instead offered a model knowledge base that is founded on the work of practitioners, noting that practitioner knowledge would need to be transformed into professional knowledge as part of the process.

A third example involved collaboration among researchers from the Instructional Research Group, researchers from the University of Oregon, teachers from an elementary school, and the creators of Peer Assisted Learning Strategies (PALS) in Mathematics (Baker, Gersten, Dimino, & Griffiths, 2004). The researchers investigating the benefits of this collaboration found that success in sustained use of the program could be attributed to initial training, ongoing support, teacher engagement, ongoing learning and reflection, teacher autonomy, and alignment to state standards. These methods clearly valued teacher knowledge and work while also providing support to enhance teacher understanding; yet each success could have only been attained by the inclusion of each member of the collaboration (Baker et al., 2004).

Collaborations and partnerships are not without their challenges. Baumfield and Butterworth (2007) acknowledged the importance of mutual benefits and the challenges that can arise from different expectations. Besides the potential for miscommunication about intent of the research, other outside factors such as politics and money can inhibit success in a collaboration (Schuck, 2013). Baumfield and Butterworth (2007), however, suggested making sure to ask questions that are of mutual interest, allowing for appropriate discussion within a research framework, and staying flexible as the roles of each party are negotiated as requirements of a successful partnership.

Design Research and Implementation Research

In what could be described as a unique combination of the desire of action research to solve a specific problem and the partnership aspect of collaboration, design research was founded on the pioneering work of Brown (1993). Brown described her innovative approach to education research as both creating an intervention as well as testing that intervention, while balancing the daily needs of an actual classroom. Sandoval and Bell (2004) expanded on Brown’s work, acknowledging the “tension between the desire for locally usable knowledge on the one hand and scientifically sound, generalizable knowledge on the other” (p. 199). Sandoval and Bell described the complex nature of design research, specifically recognizing the multiple disciplines it draws from and the balance of learning theories with the unpredictable nature of a classroom environment. Their definition of design research included work that is “theoretically framed [and] empirical research of learning and teaching based on particular designs for instruction” (p. 200). They went on to define the goal of this research method as “developing effective learning environments and using such environments as natural laboratories to study learning and teaching” (Sandoval & Bell, 2004, p. 200).

Similarly, design research has been utilized more recently by Ormel et al. (2012) and by Penuel et al. (2011) as a strategy for addressing an educational issue in partnership with teachers that supports the development and implementation of a solution. Design research serves as a bridge to the research-practice gap as it values the nuances of a classroom setting and teacher voices and makes the results accessible and applicable to other teachers, while also contributing to theoretical knowledge and innovative solutions (Ormel et al., 2012; Penuel et al., 2011). To differentiate design research from prior educational research, Penuel et al. (2011) suggested that while previous research questions may focus on “what works,” design research focuses on “what works, when, how, and for whom?” (p. 335). While these questions are quite complex, Penuel et al. (2011) acknowledged the importance of including multiple designs and methods to attempt to adequately answer such questions.

Similar to design research, implementation research focuses on the “development and testing of innovations” (Penuel et al., 2011, p. 331) and uses research of cognitive processes to guide increased achievement and instructional change, especially in mathematics (Confrey et al., 2000). Penuel et al. (2011) explained the benefits of design and implementation research as the best of all possible worlds because it focuses on teacher-identified educational problems, uses an iterative and collaborative model, applies relevant theoretical knowledge, and focuses on creating a sustainable change. Confrey et al. (2000) emphasized the importance of a strategic approach used in implementation research, including systematic measures of change, data analysis, and model building that incorporated influences that were previously unaccounted for. As with design research, the advocates for implementation research claim adaptability as a benefit of this unique type of collaboration. Other types of similar practice-based research include effectiveness research ("research that attempts to translate empirical findings and examine the effects at the applied level" (Chafouleas & Riley-Tillman, 2005, p. 455)) and intervention research (research that produces knowledge for classroom practice (Brown, 1993)).

Yet as with any type of solution to the research-practice gap, challenges do arise. Constraints imposed by governmental or educational agencies, such as the need for a quick solution and funding inconsistencies often limit the ability of design or implementation research to be carried out successfully (Penuel et al., 2011). With benefits that could potentially help to close the research-practice gap and accelerate student achievement, design research and implementation research should continue to be pursued because "the remedy [to the research-practice gap] involves working to change the relationship between the scientist and practitioner from one in which the researcher produces new research findings and the practitioner uses the findings to a dynamic, ongoing, alliance" (Forman et al., 2005, p. 572). For such an alliance to be successful, shared goals, a long-term commitment, mutual stakes in planning, and communication are needed from both researchers and practitioners (Forman et al., 2005).

Gaps in the Literature

With the goal of high quality mathematics instruction accessible to students across the country, the use of research-based practices is one way to increase student achievement (Boaler & Staples, 2008; Desimone, Smith, Baker, & Ueno, 2005; Hamilton et al., 2003; McKinney, Chappell, Berry, & Hickman, 2009; Silver & Stein, 1996). Yet even when these practices are stated as the goal of teachers in the mathematics classroom, they are often not enacted in ways that bring about desired outcomes (Boaler & Staples, 2008; Hiebert & Stigler, 2000; Huffman, Thomas, & Lawrenz, 2008; Leikin & Levav-Waynberg, 2007; McKinney et al., 2009; Star et al., 2015). This study seeks to fill a gap in the literature by investigating one aspect of teacher support that may increase the use of research-based instructional practices: teacher-researcher partnerships. The use of research partnerships, in which schools and teachers partner with universities or other research-based organizations, as a means of teacher support can close the research-practice gap by creating a collaboration in which teachers have access to research-based strategies, teachers become part of the knowledge-creation that occurs during research, and researchers become more familiar with the realities of an actual classroom (Burns & Ysseldyke, 2009; Everett, Luera, & Otto, 2007; Skovsmose, 2006; Slavin, 2013). With current research finding such benefits to research partnerships as changes in teacher beliefs, knowledge, and motivation; the ability to adapt a curriculum to an individual classroom or school; increased use of innovative classroom practices; sustained use of new practices; and the ability to solve classroom-specific problems (Baker, Gersten, Dimino, & Griffiths, 2004; Baumfield & Butterworth, 2007; Confrey, Castro-Filho, & Wilhelm, 2000; Cooper, 2007; Evans, Lomax, & Morgan, 2000; Nonis, 2008; Penuel, Fishman, Cheng, & Sabelli, 2011; Vetter, 2012), it is possible that these partnerships could have a positive impact on the use of research-based classroom practices. However, a direct connection between research partnerships and the increased use of specific practices has rarely been studied. Instead, prior studies have largely focused on essential characteristics of successful partnerships (Cooper, 2007; Forman et al., 2005; Schuck, 2013), the effect of partnerships on teacher motivation (Baumfield & Butterworth, 2007), programmatic innovations derived from partnerships (Baumfield & Butterworth, 2007; Ormel et al., 2012; Penuel et al., 2011; Stein et al., 2013), expert knowledge (Baumfield & Butterworth, 2007; Hiebert et al., 2002), sustained use of practices after a partnership ends (Baker et al., 2004), and the challenges of research partnerships (Baumfield & Butterworth, 2007; Penuel et al., 2011; Schuck, 2013). With the intent of focusing on how the increased use of a new practice in the mathematics classroom could impact student achievement, Star et al. (2015) found a lack of use of the intended practice to be problematic, contributing to their calls for future research to focus on how to increase the adoption of these practices in the first place. Alternately, much has been written about the importance of partnering with teachers to develop new curricular materials, such as the Connected Mathematics Projects for example (Lappan & Phillips, 2009), but no study has directly analyzed the impact of these partnerships on teachers' use of any new instructional practices. In fact, Phillips herself admitted, "we have never taken the time to discuss this important relationship" (B. Phillips, personal communication, January 5, 2016). It is this gap in the literature this study aims to fill.

The importance of this study lies in the fact that while research-based practices have provided increased learning opportunities for some students, especially with regards to the achievement gap (Boaler & Staples, 2008; Silver & Stein, 1996), results are not entirely consistent (Confrey & Stohl, 2004). With positive impacts for teachers' instructional practices and student learning coming from research partnerships, this study could provide insight into how research partnerships could specifically promote research-based practices. Ultimately, the goal of this study is to add another dimension to already existing literature about how to better implement instructional changes that increase mathematics learning for all students.

Theoretical Framework: The Case for Research Partnerships

Consensus on the best strategies for educational change in mathematics is largely impossible with theoretical and empirical research espousing various, sometimes oppositional, treatments that show academic gains for students. Even when one strategy may work in some circumstances, that same strategy may not be successful when the circumstances change. In an attempt to better facilitate lasting and universal changes to instruction to better educational outcomes in mathematics, the role of the teacher is critical. Cochran-Smith and Lytle are two researchers that are well known for pushing the importance of teacher-based research. As a theoretical perspective to teacher change, they suggest using an inquiry stance, which involves continual reflection, questioning, and collaboration. With a large focus on collaboration, they suggest that educational transformation comes by putting the knowledge and experiences of teachers at the center of any attempt for change, with the goal of "generating deeper understanding of how students learn" (Cochran-Smith & Lytle, 2009, p. 58).

A growing body of research has examined the impact of teacher inquiry on mathematics practices specifically. As a teacher-educator, Marin (2014) suggested that using inquiry to guide teaching parallels and integrates the use of inquiry in mathematical thinking. Taton (2015) also called for teacher inquiry, using the process of mathematics inquiry among teachers as professional development to create transformative practices in the classroom. He argued for the importance of teachers experiencing authentic mathematics, including knowledge creation, as a prerequisite to creating authentic learning experiences in the classroom. With the goal of integrating technology into mathematics education, Tyminski, Haltiwanger, Zambak, Horton, and Hedetniemi (2013) held the same perspective about the importance of teacher learning paralleling student learning. Additional studies have investigated the use of teacher inquiry in the development of understanding mathematics instructional practices, finding that inquiry served as a form of professional development and fueled collaboration that helped teachers understand mathematics pedagogy (Jao & McDougall, 2015; Lotter, Yow, & Peters, 2014). Many researchers in mathematics education are concluding that inquiry teaching directly models the practices of mathematics inquiry (Marin, 2014).

Using an inquiry stance for classroom change requires that teachers become creators of new knowledge and that this knowledge is shaped through collaboration when teachers address problems in their practice (So, 2013). Ball (1996) suggested a shift from implementing new programs of instruction to adapting new programs could occur with an inquiry stance towards practice, focused on collaborating and grappling with new ideas while considering other ideas and resources. Because this knowledge is directly impacted by the reality of the day-to-day classroom, it is hypothesized that it would be more relevant to teachers and more relevant to implementing change.

Studies have found that using an inquiry stance does indeed generate new knowledge both from and for teachers and relates directly to teaching practice (So, 2013). The inquiry stance approach towards instructional change can also help to mediate the research-practice gap by acknowledging that teachers can seek new and valuable knowledge and contribute to classroom instructional theory as well (Ball, 1996). However, challenges have also arisen when using the theory of an inquiry stance at schools, including the difficulties teachers have creating the structures for research and accepting the responsibility for knowledge creation (So, 2013).

In 1996, Ball suggested using curriculum materials and videotaped teaching as the starting point of teacher inquiry. This paper proposes an alternative view of using research partnerships as the starting point of teacher inquiry, knowledge creation, and instructional change for mathematics classrooms. Engaging in a research partnership allows teachers to be directly engaged in the creation of new knowledge with researchers. Combining the theoretical and empirical expertise of researchers with the experiential, practical, and community knowledge of teachers provides for opportunities to close the research-practice gap and create new knowledge that is both cutting edge and useable. By reviewing the literature on teacher attitudes, teacher ownership, and instructional change, this type of partnership can provide the ownership teachers need leading to a better attitude about the new practice. Finally, changes to teacher attitudes can create more consistent use of research-based practices.

Inquiry stance is one perspective that changes the new-practice implementation narrative from teachers being "receivers" of knowledge to "creators" of knowledge (Cochran-Smith & Lytle, 2009). Thinking back to the CAMCC, research partnerships complement this model of change. The CAMCC emphasized the importance of teacher reflection and processing, which would become integral in a research partnership. Because most teachers believe that only knowledge deeply rooted in the daily struggles of a classroom can serve to bring meaningful change, using an inquiry stance is one way to promote change in the classroom. Believing that the role of the teacher is critical to reform efforts and that teachers themselves can generate meaningful knowledge to transform their classroom, it is suggested that collaboration between researchers and teachers could help facilitate the creation of meaningful, classroom-based knowledge in an efficient manner, employing the talents of both parties to best address educational challenges.

When attempting to implement new practices in the classroom, teacher ownership of change is an important part of a multi-dimensional solution to improved educational outcomes (Coburn, 2003). However, Evans et al. (2000) reflected that "teachers' voices are rarely heard amongst the many who proclaim about what needs to change in schools in order to improve them" (p. 416). They go on to suggest that it is critical teachers' voices are actively sought out when designing strategies for improved outcomes. The solution to implementing change in the mathematics classroom may ultimately be complex, but it must include teachers' voices and an awareness of the importance of their role. In this way, research partnerships – an opportunity for practitioners to engage side-by-side with researchers – can successfully impact the implementation of new practices in classrooms.

Overall, whether through action research, collaboration, design, or implementation research, "engaging practitioners in the co-creation of new knowledge… is a powerful process for promoting the uptake and use of new insights among participants" (Ormel et al., 2012, p. 968). Because bringing strong teaching practices to underachieving students, especially in mathematics, has been shown to increase achievement and success among all students, the connections between mathematics education research and instructional practice are crucial. If, as some researchers have posed, the quality of education could continue to improve by bridging the research-practice gap, then more efforts need to be made to make action research, collaborations, and design and implementation research available to schools and teachers.

The theoretical perspective of research partnerships from Power et al. (2005), which was based on school psychology, can shed some light on the components of successful research partnerships in mathematics education. Successful research partnerships do share common traits, the foremost being collaborative involvement of all parties from the beginning stages of research design, to critical decision making, and concluding with analysis and communication of results (Power et al., 2005). In a collaborative environment, authority over the research is shared, which can be a mindset shift for some researchers who may be used to controlling as many variables as possible themselves. Benefits of this type of collaboration include celebrating the expertise of all stakeholders by validating both the knowledge of prior research along with classroom expertise, instructional practices being designed with both research and stakeholders in mind, and ownership of the change among teachers leading to more likely success (Power et al., 2005). Challenges beyond shared authority that may exist include an increased amount of time and resources, potential inconsistencies across the sample population, and the fact that the generalizability of results from research partnerships remains unknown (Power et al., 2005). The largest potential for research partnerships lies in the ability to "advance towards enhanced educational practices and to improve practical knowledge and teaching for all teachers involved" (Lopez-Pastor et al., 2011, p. 168).

To reach the goal of increased student achievement in mathematics, research partnerships present a non-traditional form of professional development that provides a powerful learning experience for teachers as well as the ability to transfer that learning into a complex system. Knowing that the implementation of new practices that affect student learning of mathematics is impacted by teacher beliefs and attitudes and professional learning experiences, research partnerships have the possibility to address both while acknowledge the importance of teacher ownership as a theory of change. Through partnerships, teachers are involved in the inquiry process, leading to their own reflection of their beliefs and attitudes. Professional learning has often been cited as a main benefit to these partnerships as well. Teacher learning is nested within many interdependent systems, and as such "one must consider what sort of local knowledge, problems, routines, and aspirations shape and are shaped by individual practices and beliefs" (Opfer & Pedder, 2011, p. 379). Research partnerships create an opportunity to adapt research into specific learning environments. While teachers may do this regularly, the partnership with researchers allows for such changes to be recorded and analyzed for their impact on the outcome (Power et al., 2005). Working with the very complex system of teaching and learning, research partnerships allow for knowledge to be adapted to local contexts and for a celebration of the best of expert knowledge in research and in practice through collaboration, effectively ending the research-practice gap when implementing new practices (Opfer & Pedder, 2011).

By examining one specific partnership, this study answered the following research questions in an attempt to understand the benefits arising from a collaborative research partnership on teaching practices:

a. How do mathematics teachers view their own participation in a teacher-researcher partnership?
b. How does the implementation of a new mathematics practice differ between teachers who participate in a teacher-researcher partnership and those who do not?
c. What features of a teacher-researcher partnership support the implementation of new practices in mathematics classrooms?

CHAPTER 3

METHODOLOGY

Context for the Study

This study investigated teachers' views of their role in a teacher-researcher partnership, the differences in implementation among teachers who engaged differently with researchers, and the key features of the partnership by using secondary analysis of data provided by the AlgebraByExample research partnership (See Booth et al., 2015). This partnership involved multiple organizations: the Minority Student Achievement Network (MSAN), the Strategic Education Research Partnership (SERP), and two research universities. MSAN is a national network of school districts that have committed to studying and closing the achievement gap in their districts. SERP is an independent, non-profit institute with the explicit goal of facilitating collaborations between researchers and practitioners. In 2006, members of SERP and MSAN began working together to address a critical area of need identified by participating school districts: learning algebra 1 content. Researchers from the two universities were brought into the dialogue to provide theoretical and research-based knowledge, and the specific task of ending student misconceptions about algebra 1 content was set forth. Through the partnership, a set of supplementary materials called AlgebraByExample was created and field-tested through an iterative process (Booth et al., 2015).

AlgebraByExample uses correct and incorrect worked example problems with self-explanation prompts paired with procedural practice problems to decrease student misconceptions and increase student learning. An example assignment is included in

Appendix A to demonstrate how the worked example problem connects with the practice problem. AlgebraByExample contains 42 assignments organized around 9 major topics most commonly taught in algebra 1; each assignment can be used individually or in combination with other learning material. AlgebraByExample is designed as a supplement to teachers' already-existing curriculum and can be used to support research-based practices (Booth et al., 2015).

The Common Core State Standards (CCSSI, 2012) are currently dominating the discourse in mathematics education, designating both content *and* practice standards. Unique from most state standards, the Common Core designated Standards for Mathematical Practice (SMP), which sought to mandate research-based practices. These practice standards focus on student actions such as "make sense of problems," "reason abstractly and quantitatively," "construct viable arguments," and "model with mathematics," among others (CCSSI, 2012). These practices align with the NCTM vision for mathematical processes.

The AlgebraByExample project and materials represent a shift in classroom practices for teachers and align with the goals of reform-based mathematics practices as defined most recently by the Common Core Standards for Mathematical Practice (SMP). While justification of alignment could be made for each of the SMP, AlgebraByExample supports four of the practice standards more specifically. The first practice standard, "Make sense of problems and persevere in solving them" (CCSSI, 2012), asks students to "[explain] to themselves the meaning of a problem…" This represents the goal of the AlgebraByExample project's use of self-explanation prompts. Additionally, the first practice standard asks students to interpret solutions, analyze similar problem types, explain relationships within the problem, understand and connect different problem solving strategies, and ultimately check to see if the answer makes sense given the context of the problem. The AlgebraByExample self-explanation prompts give teachers the opportunity to ask each and every type of question in this new practice within a given assignment. Similarly, the probing nature of these prompts also aligns the AlgebraByExample work to the second practice standard: “Reason abstractly and quantitatively” (CCSSI, 2012). This standard asks students to both decontextualize and contextualize a problem situation, as well as pay attention to units and the meaning and quantities. The self-explanation prompts continue to give teachers the opportunity to bring this type of mathematical understanding into daily classroom practices. Finally, AlgebraByExample also aligns meticulously well with practice standards 3 (“Construct viable arguments and critique the reasoning of others) and 6 (“Attend to precision”) (CCSSI, 2012). The nature of worked examples allows students to view the reasoning of another student and allows for safe critiques within classroom discussions. AlgebraByExample supports attending to precision by giving students opportunities to practice clear communication and drawing students’ attention to the precise meaning of all parts of the problem, when needed.

AlgebraByExample is a tool created in partnership between teachers and researchers with the specific purpose of ending algebraic misconceptions. To do so, this tool relies on many of the Common Core Standards for Mathematical Practice, which asks teachers to shift the way they are teaching by incorporating new strategies and practices in the classroom (Lange, Booth, & Newton, 2014). Based on the partnership already established among the two universities, SERP, and MSAN, as well as the

AlgebraByExample materials developed to support student learning and the Common Core Standards for Mathematical Practice, this study investigated how the partnership aspect specifically influenced teachers' use of instructional practices in the classroom.

Research Design

Qualitative secondary data analysis was used to analyze data collected through the SERP (Strategic Education Research Partnership)-MSAN (Minority Student Achievement Network) partnership in collaboration with researchers at two universities. Beginning as a collaboration between researchers and teachers to solve the teacher-identified problem of persistent misconceptions in algebra 1 courses, the team enlisted researchers at two universities to help develop AlgebraByExample, a collection of problem-sets utilizing worked examples paired with self-explanation prompts. After undergoing various stages of developmental testing, a year-long study was completed during the 2012-2013 school year. During this study, teacher observations were completed and recorded; mid-year and end-of-year teacher surveys were collected; and teachers were interviewed. It is this data from the 2012-2013 year that was used in this study (Booth et al., 2015).

Participants

Twelve teachers completed the year-long study with their students. Five of these teachers (David, Brooke, Charlotte, Isabel, and Audrey) had been participating in a working group – a direct collaboration opportunity between the researchers and the teachers where teachers gave feedback and advice and researchers could explain the theoretical background of the work – for multiple years. Three teachers (Marco, Kate, and Andy) joined the working group for the first time during the 2012-2013 school year;

thus they were new to the experience of collaborating with researchers. Four teachers (Nick, Travis, Valerie, and Molly) did not participate in the working group. Comparing the teachers who were in the working group for multiple years, to those who just started, and to those who were not, all of whom did utilize the same new material in their classroom, allowed me to investigate differences in implementation and potential for sustained use based on interactions with researchers.

Additionally, four mathematics coordinators (Daniel, Will, Jessica, and Adam) participated in the working group along side both teachers and researchers. The mathematics coordinators were district personnel tasked with organizing the teaching and learning of mathematics for their respective school district, sometimes coaching or serving as an administrator. The coordinators completed interviews and survey data from their perspectives; the information gathered from these coordinators will be viewed as a data source, though the coordinators are not direct participants in the study and did not instruct using the AlgebraByExample materials.

Participation in the entire study, as well as in the working group, was voluntary. The only selection criteria was teaching in an algebra classroom. Researchers were not involved in the selection process. Instead, math coordinators helped to facilitate the selection process, sometimes making the choice of who served in the working group if necessary.

All of the teachers and mathematics coordinators came from five different school districts that were part of the MSAN network. MSAN school districts share many characteristics: they have student populations that range from 3,000 to 33,000; they are located in mid-size cities or suburbs near a larger city; and they have a diverse student population with gaps in achievement based on race. Profiles of working group teachers and mathematics coordinators are provided in Table 3-1 to provide additional background information and context on the teachers that worked closely with researchers. (The information was not available for the remaining teachers). The names of all teachers and coordinators have been changed to protect their identities.

Table 3-1. Working Group Participant Profiles

Name	Role/Years with Working Group	School Level	Relevant experience
David	Working group teacher – 4 years	High school	6 years teaching algebra & geometry
Brooke	Working group teacher – 4 years	Middle school	18 years teaching math
Charlotte	Working group teacher	Unavailable	Unavailable
Isabel	Working group teacher – 4 years	High school	Entered teaching as a career changer many years ago
Audrey	Working group teacher – 3 years	Middle school	21 years teaching math
Marco	New to working group	High school	Unavailable
Kate	New to working group	Middle school	Unavailable
Andy	New to working group	Unavailable	Unavailable
Daniel	Math coordinator with working group – 2 years	All secondary	Served as engineer for 4 years before switching to teaching and then to resource teacher
Will	Math coordinator with working group	All secondary	Career change to teaching and now to coaching mathematics
Jessica	Math coordinator with working group	Unavailable	Unavailable
Adam	Math coordinator with working group – 4 years	Middle school	Math teacher turned administrator for 20 years

Measures

Multiple sources of data have frequently been used in prior research of teacher practices in attempts to gain a more accurate picture of a complex topic (Baker et al., 2004; Balfanz, Mac Iver, & Byrnes, 2006; Schoen, Cebulla, Finn, & Fi, 2003; Tarr et al., 2008). Based on similar sources used in other studies, this study used classroom observations, teacher surveys, and teacher interviews to better understand the use of new practices in the mathematics classroom.

Classroom Observations

Classroom observations of teachers' practices have often been used to document the effects of curriculum or other reform-oriented measures on the actions of teachers (Baker et al., 2004; Roehrig, Kruse, & Kern, 2007; Tarr et al., 2008). Although prior studies have differed in structure, they all used an observation protocol internally to gather consistent data on instructional practices. For example, Baker et al. (2004) utilized a curriculum-specific implementation measure and had a corresponding observation protocol and an alternate observation protocol for their control classrooms. Roehrig et al. (2007) used the Reformed Teaching Observation Protocol (RTOP) to score each observation in their study of the implementation of a reform-based chemistry curriculum. The AlgebraByExample study also used a consistent observation protocol for all teachers (see Appendix A), based on an iterative development process consistent with the project's goals.

Observations of each participating teacher took place at least three times throughout the year by nine trained observers. Each observation included detailed notation of the class logistics and demographics, how the teacher used the

AlgebraByExample materials, student and teacher actions during the use of AlgebraByExample materials, dialogue about the materials, and teacher attitudes towards the materials (collected after the class left the room). Observers visited and completed observations for 12 classes of teachers who participated in the working group, 15 classes of teachers who were new to the working group, and 15 classes of teachers who did not participate in the working group, for a total of 42 observed classes.

Teacher Survey

Surveys were administered at two times during the year (middle and end) to all teachers in the study as well as at the end of the year only to the mathematics coordinators. While surveys are a form of self-reported data, which can have a natural bias, this survey data was supplemented with other sources of data to understand a broad picture of teacher practices.

The mid-year teacher survey (see Appendix B) contained questions about the logistics of implementing the materials, solicited feedback from teachers on the implementation procedures, questioned teachers' use of the materials, and asked for teacher feedback regarding the specific strategies derived by the materials. The survey also asked for additional feedback, such that teachers could communicate with researchers about any thoughts, questions, or concerns. Four out of the five working group members responded; all three teachers who were brand new to the working group responded; and only one out of the four non-working group members responded. The end-of-year survey (see Appendix C) also included logistics questions, but additionally asked teachers' about potential future use of the material, perception of the strategies encouraged by the material, and for overall benefits and concerns with the materials. The end-of-year survey had a greater participation rate, with all twelve teachers in the study responding as well as all four mathematics coordinators.

Interviews

The interviews conducted in the original study were done so for informal purposes of the researchers. Teachers, mathematics coordinators, and researchers were interviewed. This study analyzed the interviews of six teachers who participated in the year-long study during the 2012-2013 school year as well as those of three mathematics coordinators. The questions to teachers and coordinators centered on similar topics, but were not standardized, as the interviewer often responded to or expanded on teachers' answers. Examples of interview topics with the teachers and mathematics coordinators included what led the teacher to participate in the project, perspectives on teaching mathematics in general, and their experience with the AlgebraByExample project. The researcher of this secondary analysis study transcribed the interview questions and answers.

Method

By using qualitative analysis, the ways in which the research partnership related to the use of research-based instructional practices in mathematics classrooms was explored. A qualitative analysis was selected as the best way to answer the research questions. According to Creswell (2009), qualitative analysis is most appropriate when the following characteristics exist: a "natural setting," "multiple sources of data," "inductive data analysis," and more (p. 175). This particular study used multiple sources of data that were collected in the natural setting of teachers' classrooms. Among the observations, surveys, and interviews, the goal was to seek out patterns to understand the experiences of teachers in the partnership.

The specific qualitative strategy used to analyze the data was phenomenological in nature, specifically an Interpretative Phenomenological Analysis (IPA). The key component to phenomenological research is to understand the experiences of a specific group of people through analysis of patterns, relationships, and meaning-making (Creswell, 2009). Phenomenology has recently been used frequently among education researchers; it has been described as "an approach which has been used to research teachers' conceptions across the world and which is sensitive to contextual differences" (Taylor & Booth, 2015, p. 1304). For example, Yurdakul (2015) used a phenomenological approach in studying elementary teachers' perception of curriculum, and Taylor and Booth (2015) used a similar approach in studying the conceptions of teaching among secondary science teachers confronting instructional change. The specific approach of IPA is described by Smith, Flowers, and Larkin (2009): "IPA is a qualitative research approach committed to the examination of how people make sense of their major life experiences" (p. 1). IPA includes more than just phenomenology alone, and instead is a combination of "(a) phenomenology, the study of lived experience; (b) hermeneutics, the theory of interpretation; and (c) idiography, which is concerned with uncovering the particularity of a specific phenomenon" (Bleiler, 2015, p. 234). It is this particular combination that made this approach appropriate for this study, as interpretation and uncovering were as important as the lived experiences of teachers. Bleiler (2015) used IPA to study collaboration and interactions among mathematicians and mathematics teacher educators. IPA was well suited to answer the research questions addressed in this study, and prior research has shown benefits of using IPA or other phenomenological techniques to study teachers, the nature of change, collaborations, and instructional understanding.

"Secondary analysis involves the re-use of pre-existing qualitative data derived from previous research studies," (Heaton, 2008, p. 34) and can be "used to investigate new or additional research questions" (p. 35). Secondary analysis has traditionally been used on quantitative data, but a growing body of research demonstrates the usefulness of secondary analysis on qualitative data as well (see Heaton (2008) for a review of research involving secondary analysis of qualitative data). In this study, secondary analysis was used to examine additional research questions that were not afforded in the original study. Some researchers have found secondary analysis of qualitative data to be controversial, with the primary concerns being understanding the original context of the research, potential breaches of confidentiality with interview subjects, and data-sharing issues (Heaton, 2008; Medjedović, 2011). The current study was conducted with research questions that aligned to the overall goals of the original researchers (research partnerships), with the secondary researcher having close knowledge of the original study. Interview subjects were told that their interviews were going to be used to understand the project on a broader context, so no breach of confidentiality existed with the exploration of a specific question within the context of the interviews. And finally, all data sources were shared in-kind. Ultimately, Medjedović (2011) concluded that the benefits of secondary analysis of qualitative data outweigh the potential controversies.

Data Analysis

Data from the 2012-2013 year-long study of the implementation of AlgebraByExample in classrooms and the teachers' interactions with researchers was analyzed using an iterative, systematic approach of coding for patterns and factor identification in interviews, surveys, and observations (Bleiler, 2015; Smith et al., 2009). Following the guidelines for IPA from Smith et al. (2009), this process began with reading and re-reading initial interview questions, transcripts, surveys, and observation data. An annotated note-taking and pattern analysis process was used to minimize bias as the researcher worked with data from multiple participants.

The note-taking and pattern analysis process was completed using four steps. The process was completed in totality for each data source before moving on to the next one. The first step of this process was exploratory noting and was completed by recording raw, interpretative notes side-by-side with the original documents (see Appendix D for examples). This act of noting focused on descriptive content, linguistic analysis, and conceptual questions. The second step was to gather all of the exploratory notes for each participant and search for commonalities. These commonalities were grouped together to form themes (see Appendix E for examples). The third step was to look for connections among themes (see Appendix F for examples); this process was repeated for each participant. The fourth and final step of the IPA process was to find recurrent themes among participants. In this study, this occurred by copying all connecting themes for each participant into one document and looking for similarities among the connections (see Appendix G for examples). Themes and connections were primarily found through abstraction (grouping and renaming clusters), subsumption (one theme brings together other themes), and numeration (frequency). The annotated note-taking and pattern analysis process was repeated for each of the data sources.

Teacher interviews were analyzed to investigate the first research question: how do mathematics teachers view their own participation in a teacher-researcher partnership? To identify the differences in the implementation of a new mathematics practice (research question two), the interview data, observation data, and the mid-year and end-of-year surveys was all utilized. To identify the features of the teacher-researcher partnership that supported the implementation of new practices in the mathematics classroom (research question three), both the interview data and mid-year and end-of-year survey data was used. Teachers who participated in the working group versus those that did not were compared to see if any comparative or contrasting themes arose.

Justification

Studying the impact of a specific curriculum or support structure on teachers' use of research-based instructional practices has a significant amount of literature upon from which to draw. While the gap that this study sought to fill lies within the type of support structure for teachers (in this case, a research partnership), the extant literature provides a solid basis for a qualitative study based on multiple sources of data. Using a phenomenological design with secondary analysis allowed for an investigation into the lived experiences of the teachers as they implemented new practices in their classroom. The potential for a comparison between teachers who participated more closely with researchers and those who did not existed. Specific methodological choices were made based on a review of the literature, combined with practical considerations of time and resources, a desire to utilize many sources to understand instructional practices and choices from various points of view, and respect for the original study. Based on a synthesis of the available types of data that could be used to answer the research questions, the teacher surveys, classroom observations, and teacher interviews were chosen. Emerging considerations of the Common Core State Standards and the impact they have on classroom instruction also affected the methodological choices. Even though many Common Core-related aspects of instructional practice have not been fully researched, the methods used to measure instructional practice still applied.

Limitations

Even with the previous considerations, limitations of this study existed. One limitation was the inexact nature of measuring teacher practices. While this study attempted to minimize this limitation by using three sources of data to understand teacher practices, none may necessarily represent the exact classroom environment. Completing secondary analysis on previously collected data also presented limitations, the main one being that the questions asked to participants were not controlled by the current researcher. No measures of teacher knowledge were originally included in the data collection. Additionally, the researcher did not have direct access to actual classrooms or recorded discussions that occurred around the AlgebraByExample materials. This limitation means that no analysis of the quality of the discussions could be conducted.

Another limitation was that teachers self-selected to participate in the working group, which could have created a selection bias when comparing the results among groups who participated with the researchers in different ways. There was no initial measure of teaching practices either, which could have helped negate the effects of a selection bias. Finally, phenomenology is based on interpretations, and with any interpretations comes bias. Attempts to minimize bias existed by the acknowledgement of previously held educational beliefs. The purpose of phenomenology is to understand participants' experiences, so all efforts were made to let the participants' words and actions guide the analysis. All of these limitations were considered as results were analyzed and reported.

CHAPTER 4

RESULTS

Research Question 1

Interview data was analyzed using Interpretative Phenomenological Analysis (IPA) to answer research question 1: "How do mathematics teachers view their own participation in a teacher-researcher partnership?" The data indicated that participants viewed their participation through multiple lenses such as being a collaborator, being a learner, and being an agent of change.

Being a Collaborator

One way that mathematics teachers viewed their participation in the partnership was as a true collaborator. As Schuck (2013) pointed out, collaboration in the context of a research partnership is more than just working together; collaboration includes setting mutual goals, expressing mutual commitment, taking steps to solve the identified problem, and maintaining leadership rolls. In a collaborative research-partnership, teachers are involved in the "co-creation of new knowledge" (Ormel et al., 2012, p. 968). In this study, participants discussed multiple instances of collaboration in ways that indicated they were involved in the entire research process, from the initial design of the materials, to analysis of data, to reflection and modification, and finally to the creation of knowledge. This was an important distinction between the SERP partnership model and other less integrated partnership models where teachers are included in a "feedback" stage of research only.

David, an experienced working group participant, highlighted the perspective of being a collaborator in the research process when he stated, "The working group seems to be made up of teachers who are getting together to both create and edit the assignments that students will be doing in algebra classrooms." The creation of these materials in a traditional research study comes directly from the researchers, and so his words draw attention to the leadership roles and action steps teachers were involved with from the outset of the project. In fact, many teachers demonstrated commitment and pride about their involvement in the study since the beginning. The teachers who had been a part of the partnership since its inception were quick to point that out, with Brooke saying "I've been with SERP since the beginning of the AlgebraByExample study" and Isabel saying "I have been with the SERP institute since almost its inception." Adam also mentioned he had been affiliated with SERP "ever since this project began" and added, "I was in on the initial meetings."

In addition to being a collaborator when designing the materials, the interview results also indicated that teachers felt invested as a collaborator and as a co-creator of knowledge throughout the entire research process. Co-creation of knowledge is an important component of teacher inquiry, which exemplifies the totality of collaboration in a teacher-researcher partnership as both parties are involved in the goals and outcomes. Will was one of a few interviewees who specifically articulated a desire to interpret the results of the study. He stated, "I'll be interested to see if it's proved that [AlgebraByExample] is actually supportive of our students." Just like researchers themselves, the teachers as collaborators felt invested in both learning the results and continuing the research process as an ongoing cycle of data analysis and iterative change. Discussing the data and reflection process, Isabel stated:

> I know from experience and after coming to the second iteration of SERP that the long-term study showed some growth, but it was very difficult to take that massive amount of data and actually find a trend. So, I was really thankful that when we came back and we started the next iteration, that we started off with a short term and worked up to the year-long.

Her statement showed her investment with both the data and the iterative nature of the research process. Similarly, Audrey expressed an awareness of the data analysis process by describing the stage in which researchers do demographic analysis and attempt to find the benefits of the program.

Marco, a teacher who was brand new to the working group, provided a unique perspective on the collaborative research process and the co-creation of knowledge. As a new member, he had not worked with researchers prior to the day of his interview. From the perspective of an outsider looking in, Marco noticed what both Will and Isabel described:

> It's clear that the other districts, and the teachers from all the districts who have been participating for years, feel invested in making sure that the data is adding to the store of human knowledge about teaching and learning.

This perspective indicated that collaboration occurred throughout the entire research process, including data analysis and reflection and the contributions of teachers to the body of knowledge about mathematics education.

Collaboration can provide a sense of ownership, which is a critical component of teacher change. Teachers did assert claim to the work created in the partnership, indicating that as collaborators, they were full owners of the project and materials. This ownership became apparent through teachers use of the pronoun *we*. As quoted above, Isabel felt thankful when "we came back," "we started the next iteration," and "we started off…." Brooke also recognized her role as a collaborator through the shared responsibility for revision work when she described "all the different revisions that we've gone through." The use of the pronoun *we* emphasized that most of the participants saw themselves as deeply embedded in the whole research process as a collaborator. Brooke similarly indicated ownership of the entire partnership with her use of the pronoun *we* when discussing problem solving processes that occurred as the SERP partnership evolved: "We've figured out a way to do things, so that it isn't so difficult for teachers."

One teacher, Audrey, an experienced working group participant, had a noticeably different approach when speaking about the collaborative research process than all of the other participants. Her statement indicated a disconnect between the researchers writing the questions in the materials and herself. Audrey stated, "What the AlgebraByExample writers have done is put in [students'] very common mistakes, common misconceptions, things that we frequently see as math teachers." Audrey made a clear distinction between the writers of the problems and herself as a mathematics teacher. Of the experienced working group participants (seven of whom were interviewed), Audrey is the only one to refer to the researchers as *they.* All of the remaining participants use the pronoun *we* when discussing the research process. In these ways, the interview data indicated that a sense of collaboration was found among experienced working group teachers, and that the teachers were integral to the entire research process.

Another indication of collaboration appeared through teachers' pride, excitement, and most of all commitment when speaking about SERP and AlgebraByExample. Isabel described a complicated process that her district required teachers to go through in order to participate in the study, one that Isabel described as requiring "diligent" work. That diligent work served to contribute more to the sense of pride and ownership felt around the program. Adam expressed "I was really quite excited" so much so that he said, "I went back and was almost ready to say this is definitely the way to go, but we had to wait and see what the research shows as to whether or not it really does help students." As the results started to come out, he also expressed he was "excited about that."

Mathematics coordinator Will explained a unique situation in which his district began with the SERP project, but had to stop due to some "transitional things;" however, his district actively sought to rejoin the partnership, and Will expressed, "We're excited to be a part of it." And from the opposite end of the spectrum, Kate, another teacher who was brand new to the partnership, was looking forward to the ability to contribute to the process, as she expressed a desire for a better understanding of the problem types so that "I could have really understood the kind of questions we were supposed to analyze."

In one situation, two individuals described a situation that indicated that as collaborators, teachers were experiencing the role of researchers through critical decision-making processes about the research. These individuals mentioned that one district grappled with ethical issues involved in the research process, just as researchers often do. Will described this issue as it occurred in his district:

> We also had some questions about some equity issues, […] one group is getting one thing, another group is getting another thing, and this was a very large conversation that we had when we were a part of the research before, and it's something that has popped up again in these two days here. So it's something we're still struggling through. If we know, if we have a strong feeling that [AlgebraByExample] is going to be beneficial for students, the fact that we're not using it with all of our students is a struggle for some of us. […] We do have some teachers that have participated before who are no longer participating in the research because

> they see such value in using the examples, that that's what they use in the class.

In Will's district, all teachers discussed the research as researchers would, ultimately making decisions about the use of the research material in their classroom and their ability to continue as part of the research study. Because these teachers were grappling with ethical research issues just as researchers themselves do, they became a full collaborator in the process, respecting the boundaries of research while also being in charge of making the best decision for their own classroom. Through shared duties and actions, a shared commitment, shared leadership roles, ownership of materials, and their roles in the creation of knowledge and decision-making processes, teachers described their experiences with the partnership as being collaborative.

Being a Learner

In addition to being collaborators, multiple teachers indicated that the SERP partnership contributed to their own professional learning and indicated that they saw themselves as learners in the partnership. In describing why she would recommend SERP to another teacher, Isabel said, "Oh, I would encourage them whole heartedly. I've learned, and my colleagues […] have also learned that through error analysis and through formative assessment – regular daily assessment – is that students learn a great deal." Adam echoed her emphasis on the learning that occurred between herself and her colleagues. Adam focused on how the learning that occurred through the AlgebraByExample partnership would help struggling learners: "I felt that the program was definitely valid, that it could lead us to some understanding of how to help students who weren't necessarily traditionally successful in algebra." Will signaled his own professional learning when he said, "I think that AlgebraByExample is important, and it has a definite place in how we teach algebra. I'm very interested in the research." In these instances, Isabel and Adam focused on learning about strategies, while Will focused on learning about the research. However, all of their statements indicated that they were participating in the partnership as a learner as well.

Finally, Marco expanded upon an individual's role as a learner to describe the SERP experience as a community of learners:

> I don't usually get a chance to get around education nerds – people who love to talk about, like, the experimental protocol and how you could make sure that your experiments is [sic] sort of valid, and how we can make education better. But everybody here loves to talk about teaching, and it's cool.

Being an Agent of Change

The final lens under which teachers in the partnership viewed their participation was as an agent of change. Brooke, for example, discussed her role in the change process:

> I think we had teachers who were resistant to change, teachers who were not resistant to change […], but I'm always willing to try new things, and so this idea that there is only one way to do something and that's the way I've done it for 15 years is just silly. So when we started doing things differently, I just sort of plunged into it. But I would say, you know, we've had teachers who over time have evolved, because after a few people do something, slowly they start hearing about things. Then they start trying them in the classroom. And some schools are easier to change than others. Mine's been pretty easy.

It is clear that Brooke viewed herself as an agent of change because she was open to trying a new strategy, started implementing it right away, and helped convince others to try it as well. Her use of the word *mine* when discussing her school's change process indicated that she saw herself as integral to the change process. Isabel similarly noted that many other teachers were inspired to use the new materials and practices after her work over many years in the program: "I began early in the program […] and the example-based assignments have inspired many teachers of algebra 1 to start using error analysis in their classroom and formative assessment as well. So, perfect."

As leaders, both Daniel and Adam saw the need for change in mathematics instruction and saw the teachers involved with this process as being agents of change as well. Daniel identified the need to "inject some more reality, some more application, some real life mathematics" into students' experiences with mathematics in schools, mentioning motivation and engagement as important artifacts of this new way of teaching mathematics. Adam noted that without AlgebraByExample, a common experience in mathematics classes includes students doing homework with misconceptions, and even after teachers address the inaccuracies in class, those same misconceptions would reappear on an exam. Clearly, both Daniel and Adam saw a need for change in some of the existing practices in mathematics classes, and they both identified teachers participating in the AlgebraByExample project as being agents to bring about this change. Daniel stated:

> This whole project can help with [the changes] in some respect because some of the problems actually do deal with real world problems; they ask students to analyze those problems; they ask students to think about them in context. So I think it's definitely a step in the right direction.

These examples indicated that teachers and leaders viewed participants' roles as agents of change. Along with being an agent of change, teachers viewed their own participation as that of a collaborator and a learner in the teacher-researcher partnership.

Research Question 2

Surveys and observations were analyzed to answer research question 2: "How does the implementation of a new mathematics practice differ between teachers who participate in a teacher-researcher partnership and those who do not?" Information gathered suggested that all teachers who participated in this study were able to articulate the goals of the implementation and of the new mathematics practices that aligned with the materials. However, differences emerged in the ways in which the practices were enacted and the AlgebraByExample materials were used. Teachers who participated directly in the partnership by interacting frequently with researchers embraced the new mathematics practices more holistically and with more intentionality than those who did not have the same experience with the researchers in the partnership.

Similarities

Data from both surveys and observations indicated similarities in the ways all teachers were able to articulate the benefits of the AlgebraByExample materials and practices. The end-of-year survey, for example, asked teachers what they liked best about the example-based materials. There was no discernable difference in the responses of teachers who had participated in the working group for many years from those who were brand new to the project or who had not participated with researchers. Working group member Charlotte wrote that students "had good discussion between themselves," while Brooke liked "how students are forced to confront their misconceptions." Non-working group member Valerie wrote the materials "lead to student discussion about problems," a similar observation to Charlotte. Molly also answered, "I really liked that the example-based problems really helped bring to my attention misconceptions that I didn't realize were there." These statements indicated that the working group and non-working group members alike were able to discern the intent and value of the AlgebraByExample materials and practices.

In the teacher input section of the observation data, teachers from the three different groups mostly agreed that there was no difference in students' motivation when presented with the AlgebraByExample materials compared to their typical classroom activities. Direct observations of classrooms also indicated that there were no noticeable trends among the different groups in how the assignments were used within the class, with the exception of two non-working group teachers who used the AlgebraByExample materials as direct instruction with the whole class. In these cases, the teacher guided all students in working through the problems, with explicit instruction on how to interpret each problem given by the teacher. In all other cases, teachers in all groups used the materials in different ways or at different times of the lesson – ranging from a start-of-class warm up to independent practice near the end of class – some using them flexibly depending on the students' needs as well. Most notably, when asked for the amount of time typically spent lecturing and taking notes versus having students working on practice problems, teachers in all groups self-reported similar ratios (working group teachers reported lecturing or taking notes during 48% of class time on average, teachers new to the working group reported 54%, and non-working group teachers reported 47%). The lecture versus problem solving question could serve as a proxy for how teachers value reform-based practices in their classrooms; in this case, no difference existed among the three different teacher groups. Additionally, teachers were asked to describe any impact using the assignments may have had on their teaching practices. Their answers indicated that a common understanding existed of how the assignments could impact such classroom practices as discussions, a focus on student misunderstandings, and formative assessment use.

Despite the similarities in understanding the AlgebraByExample materials, practices, and their benefits, the implementation of these ideas occurred very differently in classrooms. Overall, all teachers reported a positive experience with the materials, and all teachers indicated a desire to use the practices more. But even though all teachers could equally articulate the goals and benefits of the AlgebraByExample materials, the implementation of new mathematics practices differed among the teachers based on their interactions with the research partnership. Most differences occurred such that the working group teachers (those who had participated with researchers for multiple years) interacted with the materials differently than both the teachers who were brand new to the working group (those who had worked with the researchers just once before the study began and who had not been involved in the development of the materials long term) and the teachers who had no direct interaction with the researchers. Because of this, the teachers brand new to the working group and those not in the working group will be collapsed into one group and any discernable variation between these two groups will be specifically highlighted. Ultimately, the differences can be characterized by the ways in which teachers who participated in the partnership embraced the AlgebraByExample materials and by the ways they enacted the accompanying mathematical practices. Data from surveys and observations alike supported these differences.

Differences in Material Use

The first major difference in implementation between the teacher groups was in the way in which they used the AlgebraByExample materials. Teachers in the working group utilized the material more pervasively than teachers who were brand new to the working group or teachers who did not participate in the working group. This was indicated by the amount of time given to the assignments, students' actions with the materials, self-reported ability to administer the materials, the focus of discussions, intended future use of the materials, and perceived challenges.

On the mid-year survey, teachers self-reported the time limits they imposed when using the AlgebraByExample materials in their classroom. The working group teachers either didn't enforce a time limit or they gave students additional time to finish as needed. Teachers who had not been involved with the partnership for an extended period of time tended to give students a certain amount of time – usually only 10 to 20 minutes – and reported that in some cases, students did not finish the assignments. When asked how long the assignments did take, the working group teachers reported the range of 20 to 30 minutes as the amount of time generally spent on the assignments during the class. Observation data confirmed this difference as well. Based on observations, working group teachers spent 24 minutes on average engaged with the assignments, while the other teachers spent only 16 minutes on average engaged with the assignments. This difference indicated that the working group teachers either valued the AlgebraByExample assignments more as to give more time to them or spent more time drawing out important learning from the materials.

Students' actions also indicated a difference in the way the working group teachers embraced the materials. For example, students in working group teachers' classrooms all completed the tasks in the expected order that supported mathematical development, where teachers in the other groups had multiple instances of individual students not completing the tasks in the expected order. Additionally, students asked questions regarding *how* to complete the assignments in approximately 20% of observations of teachers in the working group, compared to in 40% of the observations of teachers in the other groups. Both of these differences indicated that the working group teachers were more comfortable using the materials and giving directions to students regarding these materials in their classrooms. In fact, the teacher input data that was collected after the observations indicated that 100% of working group teachers reported being very comfortable administering the materials, whereas only 70% of new teachers to the working group and only 55% of non-working group teachers reported being very comfortable.

The focus of the discussions that occurred within class time also indicated a difference between the teachers who engaged with the researchers and those who did not. From the observation data, working group teachers were much more likely to facilitate discussions about the practice problems that followed the worked examples (occurred in 50% of whole group discussions observed and 100% of small group discussions observed compared to 38% of whole group discussions and 38% of small group discussions in the other groups). In comparison, teachers who did not engage with researchers were much more likely to have whole group discussions about the worked examples (occurred in 57% of discussions observed compared to 22% of discussions observed facilitated by working group teachers). Perhaps one explanation for this unexpected pattern is that the working group teachers were able to let the worked examples speak for themselves, as students grappled with the self-explanation prompts. These teachers then followed up on the application of this knowledge on the set of practice problems, included after each worked example. Other data confirmed that the brand new working group teachers and the non-working group teachers both struggled with the implementation of the worked examples, which could explain the need for more whole-class discussion on those items.

In another show of unity, when asked on the end-of-year survey what their biggest challenge was with the implementation of the AlgebraByExample materials, all teachers answered with some variation of time constraints (i.e., having enough time to incorporate all of the assignments). Beyond that, the working group teachers did not indicate any additional challenges. The teachers who were new to the working group, however, indicated that the integration with their current curriculum was a challenge, and the teachers who did not participate in the working group indicated that logistics were a challenge. Finally, when asked if they were likely to use the AlgebraByExample materials next year, all working group teachers responded "yes." Many of the other teachers responded "yes" as well; however individuals from both of the other groups had some reservations including two teachers who wanted to adapt the worked examples without the self-explanation questions (which was a key feature of the materials). This type of desired change, along with the challenges each group of teachers noted, indicated that the teachers who did not interact with researchers might not have fully grasped the rationale of the worked example problems as desired. On the other hand, teachers who did participate in the working group and partnered with researchers throughout the implementation process were more likely to embrace the implementation of the materials.

Differences in Mathematical Practices

The second major difference in implementation between the teacher groups was the way in which they enacted the mathematical practices associated with the AlgebraByExample material. The implementation of AlgebraByExample went beyond just the use of materials in the classroom and included the integration of research-based and Common Core based practices into a teacher's instructional routine. It is in this way that teachers who had been involved with the research partnership differed significantly from those who had little interaction with researchers. This study found that the working group teachers incorporated group work, discussions, and a student-centered classroom differently than the other teacher groups.

The use of group work was the most noticeable difference among the teacher groups. On the mid-year survey, teachers in the working group reported that when students were working on assignments, they were always working with a partner or a group. However, in the other groups of teachers, only one reported having students work with a partner or a group while the remaining teachers all reported individual use of assignments. Similarly, when asked with whom discussion occurs, working group teachers were more likely to report discussion occurred within groups, where non or new working group teachers were more likely to report discussion occurred with the teacher or the whole class. The observation data confirmed this noticeable difference in use of group work as well. Working group teachers utilized group work in 90% of observed classes, whereas the other teachers used group work in 48% of observed classes. The observed instances of whole group discussion indicated the reverse trend. Whole group discussions were observed in 33% of instances in working group teachers' classrooms, while they were observed in 79% of instances in the other teachers' classrooms. Teachers who had not participated in the teacher-researcher partnership over time were more likely than the working group teachers to address students' questions as a whole group, whereas the working group teachers were more likely to address students' questions in small groups. Overall, working group teachers relied on group work and small group discussions – a desired and research-based mathematical practice – more frequently than teachers who did not have the same experiences with researchers.

The ability to support a student-centered classroom is also an indication of the implementation of high-quality mathematical practices, and this served as another difference between the working group and non-working group teachers as well. One way to distinguish a student-centered classroom is by identifying who leads the discussions in a classroom. When asked about going over assignments in class on the mid-year survey, the responses of working group teachers were more likely to indicate that a teacher stepped in to review a problem only if it was a significant challenge among their students, and the teachers used these assignments in a more responsive and formative manner. For example, working group member Audrey wrote:

> If the assignment seemed to pose questions for a good number of students, I will go over answers […] or go over specific questions that came up while they worked. The students are always told they need to check answers with at least one other student before turning in their books. For easier, more straight forward sets, that is all I do.

David similarly wrote, “Every once in a while if there is a problem that many students have, we will go over it once the assignments are collected.”

As a counter-example, new working group member Kate explained, “After the students finish with their assignment, I have them put their pencils down […] and we go over it as a whole class on the board,” and Marco responded similarly, stating, “We go over the answers as a class.” The teachers who had interacted with researchers less frequently were more likely to review all problems as a class, which indicated a more teacher-driven classroom that was not responsive or informed by student work. In fact, 32% of observed discussions were initiated by the teacher in non-working group led classrooms, compared to 17% of observed discussions initiated by the teacher in working group classrooms. During the assignment time, teachers from the working group were observed circulating and answering questions only when asked. Within the non-working group, two teachers were circulating but were also observed directing the questions, and two teachers completely led the whole class in the example-based lessons. Teachers who had not interacted extensively with researchers led classes that were more teacher-centered, whereas teachers who had interacted with researchers led classes that were more students-centered.

Finally, when students did work in groups, there was a difference in how these groups were assigned. Teachers from the working group let students choose their own partners in five out of nine instances. Teachers from the other groups never let students choose their own partners, instead assigning groups in 13 out of 14 cases based on students' seat arrangements. Student choice is a frequently cited characteristic of a student-centered classroom, one that was only present from teachers who were part of the working group.

The ability to support a student-centered classroom and the integrated use of group work and collaborative discussion are all indicators of teachers who have embraced the mathematical practices as part of the implementation of AlgebraByExample. Combined with the differences noted in the ways the teachers used the AlgebraByExample materials, significant differences in implementation existed between teachers who participated in the teacher-researcher partnership and those who did not.

This occurred despite similarities in teachers' perceived understanding of the AlgebraByExample materials and goals.

Research Question 3

Finally, the interview and survey data together were analyzed to answer research question 3: "What features of a teacher-researcher partnership support the implementation of new practices in mathematics classrooms?" Six of the nine participants discussed implementation in their interviews specifically, with many articulating aspects of instructional change. Additional information on implementation features was gathered from participants' responses to survey questions. The features of the partnership that emerged were a focus on the teacher, evolution and responsiveness, and collaboration and integration.

Implementation Challenges

Before looking at the features of the partnership that supported the implementation, it is important to note that some features provided challenges on the path to instructional change. Most of the concerns that were shared among participants regarding the implementation process dealt with the logistics of participating in a research study and the increased expectations of time.

From the interview data, when teachers cited logistics as the toughest part of implementation, most referred specifically to challenges that occurred during the first year of the study. Brooke bluntly stated, "Obviously when we first started out it was, you know, it was a bit chaotic," adding that during the first year study, "It didn't all fit together, you know, perfectly." Specifically, she noted, "Some of the early assignments were really tough. We had to pull all these labels off and put them on a piece of paper, and we kept doing it over and over and over again." This label process was a result of the research aspect of the study and put a strain on teachers' ability to implement the new materials. Audrey referenced similar challenges in implementation due to research restrictions and logistics:

> It wasn't the lessons as they are written, the AlgebraByExample, or the problem sets [that] were the problem. It was the pieces of it to keep it a research study that could be used as a, you know, blind research study. […] The confusing pieces that came in the implementation of this were not the using [of] the lessons in the classroom at all, […] but we had to make sure every student got their own paper, and that if you had a new student come in, you had to make sure they kept getting the same code on their papers that you gave them the first time, and it was making sure that I did feel comfortable because I was giving one class the work-by-example, and the other class the problem sets that were not by example, and that was where it was confusing.

Isabel also mentioned that the first year presented difficulties and related a unique challenge from a school-district requirement for engaging with research partnerships. She noted that in her school district, "they're very particular. We have to have a signed permission slip from parents so that we can participate in the study. I do believe it's the only district that has to have that permission form from the parents." It was, again, the nature of the research portion of this implementation that added to the difficult first year. As a newcomer to the partnership, even Kate identified logistics – and only logistics – as her implementation concern. When asked by the interviewer, "just coming in, what are some of the things you're still wondering about or having questions about regarding the AlgebraByExample material?", Kate answered, "I'm sure there will be nitty-gritty questions later, like if a student is absent, what do I do, or things like that."

Some logistic concerns persisted beyond the first few years and were mentioned in the survey data as well. Nick reminded the researchers that "keeping up with situations where you have a class where a lot of students enroll and drop out throughout the year" was a logistical challenge. And Isabel discussed how both "getting assignments in order" and managing ID numbers were difficult.

In the end-of-year survey responses, nine out of twelve teachers mentioned time as a significant challenge. Teachers exclusively mentioned the increased expectation of completing work in addition to their curriculum when referencing time. Some teachers claimed the assignments themselves took additional time, such as Kate, who wrote, "I had a hard time fitting [the assignments] in when I was also using my current textbook and workbook." Brooke agreed, explaining in more detail: "The biggest challenge was getting through all of the assignments that we had selected. We studied systems of equations at the end of the school year and it seemed like we had many many assignments to do at that point." Finally, Valerie concurred, writing, "I would have liked to teach some sections in the SERP workbooks to supplement my current curriculum (like absolute value), but I simply ran out class time to introduce them."

Other teachers, such as Marco, explained that "adding the SERP study requirements […] made my lesson plan calendar overflow." Besides the assignments themselves, the SERP study requirements included a pre-test and post-test before and after every unit. Audrey appreciated the classroom work but struggled with the testing as well, stating:

> The lessons take longer than what was anticipated to complete but were good complements to my teaching. The biggest concern was the time the testing took. The surveys and tests took up a good number of days over the course of the year.

Finally, Charlotte found both the assignments and the assessments time consuming, explaining, "While most of the assignments were closely related to the curriculum -

fitting in the assessments and all the assignments was somewhat challenging. I was only able to do 36 of the 40 assignments." Whether it was the assignments themselves that added additional time pressure or the tasks that were particular to participation in the research study, teachers frequently cited time as a challenge with this research partnership.

Of these two major challenges, the logistic components were subsequently addressed, and it was the ability to address these concerns and challenges due to the iterative nature of this study and the incorporation of feedback that proved to be a key feature of the partnership that did indeed support the implementation of new practices in mathematics classrooms over time. Moving past the challenges, this study found that many features of the teacher-researcher partnership supported a successful implementation process and followed a trajectory of responding to increasingly complex teacher needs. The critical components of the implementation started with a focus on materials and basic needs, followed by support for teachers learning and cognitive engagement, and ended with the integration of research and theory into teachers' classrooms. These specific features were identified as a focus on the teacher, evolution and responsiveness, and collaboration and integration, all of which will be elaborated on below.

Focus on the Teacher

The first identified feature of the partnership that supported the implementation of new mathematics practices was the focus on the teacher. Overall, the research partnership prioritized supporting and addressing teachers' needs. This was a critical foundation of implementation success because the teachers are ultimately the ones to communicate the intended learning outcomes and utilize the materials and practices developed throughout this project. Teachers must know and be able to use the materials at a basic level first as they strive to incorporate the associated research-based practices. Of all of the ways to support and focus on teachers' needs, this teacher-researcher partnership specifically developed materials that fit into teachers' existing understandings of mathematics teaching, provided materials that were easy to implement, and allowed for adaptability based on individual classroom differences.

Fit

As quoted earlier in this paper, "staff members who perceive the innovation to be consistent with their values are more likely to be committed and enthusiastic in their innovation use" (Forman et al., 2005, p. 570). The fit of an implementation to teachers' mathematical values, beliefs, and current practices is a well-researched characteristic of implementation success. Teachers in this study cited fit as one of the reasons AlgebraByExample was implemented with success in their classrooms as well. In fact, all eight mid-year survey respondents answered the question: "how often are all of the items on a single assignment well aligned with what you typically teach within 1 or 2 consecutive days?" with either all of the time, most of the time, or sometimes.

The interview data and additional survey responses shed light on teachers' interpretations of fit. Teachers discussed how the materials matched their existing mathematical practices, their beliefs and values of what were important mathematical concepts, and the Common Core Standards. Both Audrey and Brooke, for example, mentioned exact ways in which the AlgebraByExample practices were easier to implement as they expanded upon practices that were already comfortable for the teacher. Audrey explained:

> If teachers are not as comfortable having students work in groups, or if teachers are not as comfortable having students figure out for themselves where mistakes were made, if they [have] much more of a teacher centered classroom, which mine doesn't happen to be, but if they [do], then there may be some more learning curve happening for that teacher. But for those of us who already are comfortable with using materials that you're asking students to work with and grapple with and fuss over, and you're not always the one that has the answers, there wouldn't be much of a learning curve.

To summarize, Audrey surmised that AlgebraByExample implementation was difficult for teacher-centered classrooms, but easier for student-centered classrooms because the materials fit better with the student-centered practices. Brooke echoed the importance of how AlgebraByExample practices fit with her district's (albeit changing) view of the importance of student-centered classroom:

> I've always been in sort of a traditionally based classroom, and only in the past 5 or 6 years have we really turned it around to the point where [we use] much more student centered activities. And, I would say, around that time is when we started getting involved with SERP, and it sort of fit really well into what we were doing in the class, because it wasn't all the kids lined up in rows and the teacher up at the board lecturing; it was now working in cooperative groups.

Just as Audrey and Brooke cited ways in which AlgebraByExample fit with their current mathematical practices, many teachers – including Audrey and Brooke as well – cited ways in which the program also fit within their own beliefs about important mathematical concepts. At times, their comments indicated an ongoing relationship between their own learning and their beliefs. The more they learned about the AlgebraByExample materials, the more they indicated support for the practices incorporated in the program. Brooke, for example, talked about how AlgebraByExample encouraged discourse and the confrontation of misconceptions: "The strengths of doing the example-based problems is it really gets the kids talking. It really gets them talking to each other, and it really works at some of these stubborn misconceptions that they have." Audrey valued the same components of AlgebraByExample – the opportunities for discourse and the ability to confront misconceptions – while pointing out exactly how AlgebraByExample draws out these valued components of mathematics:

> What I ask students do is work together in groups, and hopefully what they are getting from it is […] an experience where they can work through the math, and read, and explain with someone else, or a group of 3 or 4 at the most, work through what's being shown to them as an example and make some sense of it for themselves. […] It gives them, in many ways, another example, but one where they have a real […] conversation starter and something to talk about that really targets the misconceptions that happen.

Audrey also noticed the responsiveness of researchers to the needs of the classroom, as she discussed the ways the AlgebraByExample writers included real misconceptions, "things that frequently we see as math teachers," from real students in the classroom."

Audrey and Brooke both indicated in interviews that AlgebraByExample supported the beliefs they each had about the importance of discussion in mathematics instruction. Travis, Charlotte, and Valerie wrote responses in the survey that also showed how AlgebraByExample supported the important practice of discussion. Charlotte wrote that "the discussion and questions it brought out amongst my students" was what she liked best about using the example-based materials in her classroom, adding that "they typically worked in pairs – and had good discussion between themselves – pulling me in when they were both confused."

In the interview data, Adam explained how he valued students confronting their misconceptions as well, but also discussed the importance of using a mathematical process in problem solving. AlgebraByExample supported this view. Adam stated:

> I feel that exposing these misconceptions and the common mistakes that kids make is an opportunity for kids to begin doing the math correctly the first time that they do it, so that they're not unlearning or having to relearn topics.

He continued: "I think the thinking is much more important for students to understand… that [mathematics] really is about the process versus just coming up with the right answer." Daniel also discussed his value of the process in mathematics, and how AlgebraByExample supported that value:

> I think that's one of the great things about the AlgebraByExample worksheets, is analyzing the mistakes, [be]cause, that is, that's part of learning. […] Too often in math class it is about just getting the answer, it's not about the process. When you are analyzing someone else's work, again whether that work contains mistakes or not, but I think it's even more valid when it contains a mistake, you're dealing with the process, not just the answer. And so I think that's extremely valuable for students; that's something they need to engage in on a regular basis.

Finally, Daniel and Audrey also discussed the ways in which AlgebraByExample fit with the expectations of the Common Core Standards for Mathematical Practice. Referencing SMP 2: Reason Abstractly and Quantitatively, Daniel reflected in his interview, "I think the part we often forget is the recontextualizing, putting it back into context and making sure we understand how it connects to that problem we originally started with." He then identified:

> I think the AlgebraByExample problems, this whole project, can help with that in some respect because […] some of the problems actually do deal with real world problems. They ask students to analyze those problems; they ask students to think about them in context.

Audrey similarly commented on her survey, “The questions get at some of the CCSS processes that are expected in math classrooms more than the Problem based questions do. The students must persevere through the questions, explain their reasoning, [etc.].”

It should be noted that there were two participants that believed the AlgebraByExample material did not fit well with their curriculum. These two respondents were from the same school district in a state that had not adopted the Common Core State Standards. On the survey, Marco explained his perspective: “It was challenging to find enough assignments that fit our state curriculum. A lot of topics in the workbooks aren't really part of [our state’s] curriculum.”

Ultimately, the AlgebraByExample problems inspired discussions, group work, productive struggle, sense-making, and confrontation of misconceptions – all important components of mathematical instructional practices. Teachers identified these components as fitting with their current practices, their mathematical values, or the Common Core Standards, and that fit assisted teachers in the implementation of the practices.

Ease of Implementation

Another way in which the focus on the teacher was an important feature of the partnership was the intentional design for easy implementation of AlgebraByExample. Two teachers discussed how the AlgebraByExample partnership made implementation easier because researchers provided specific assistance to teachers, and one teacher-leader confirmed that from his observations, teachers responded positively when assisted with basic preparations for the implementation. For example, when discussing the difficulty of logistics that included pulling off labels to keep assignments anonymous for researchers in the first round of the study, Brooke stated, "We've sort of figured out a way to do things so that it isn't so difficult for teachers." This statement indicated that the value of ease was so important to everyone involved in the project, they made specific changes to improve the ease of use in future studies.

Additionally, Audrey stated that "using the lessons in the classroom […] was actually quite natural and comfortable," and she continued, "It was just a nice set of worksheets that kind of helped by having them all there for us already." Again, these comments indicated the importance of having basic preparation materials available for teachers as they started the implementation. Finally, as a supervisor, Adam noted:

> I have yet to meet a teacher that if you do the legwork for them and show them that something will impact their instruction and help their students, very seldom would a teacher not apply it. So I think finding something that is working for students who have typically struggled, and giving teachers the understanding and the tools to do something differently in the classroom is extremely valuable.

Together, these statements indicated a collective agreement that when materials are easier to implement and when teachers receive assistance in basic preparations, the implementation will be more likely to be completed. In this partnership, this occurred by having researchers assist with the preparation of the materials. This type of support from the researchers for the teachers resulted in the ease of implementation and helped to support a change in classroom practices.

Adaptability

Frequently, the adoption of a new program requires fidelity to a specific set of requirements under which the program was researched. However, this partnership allowed teachers to adapt the new materials to their unique classroom contexts. Three teachers directly mentioned this adaptability as being beneficial in interviews, and survey data showed consistent results as well; as thus, it serves as another way in which the partnership was focused on supporting teachers and meeting their needs.

Responses to questions on the mid-year survey indicated a wide range of strategies teachers used when implementing the AlgebraByExample assignments to meet their individual classroom contexts. See Table 4-1 for the questions and answers that indicated a wide range of classroom use.

Table 4-1. Mid-Year Survey Questions and Answers Pertaining to Adaptability

Question	Possible Answer Choices	Number of respondents selecting each answer (out of 8):
After teaching the relevant material, the assignments are typically used:		
	Varies greatly by assignment	4
	I usually use them as warm ups the next day, but have given them the same day as well as refreshers.	1
	As a refresher at least two days later	2
	As practice the next day.	1
When during the class period do you typically use the assignments?		
	At the end	1
	Varies greatly by assignment	3
	At the beginning for warm ups/refreshers, or at the end when just taught the lesson.	1
	During the middle of the period	1
	At the beginning	2
Students typically work on the assignments:		
	With a partner	2
	Independently	2
	In groups of 3 or 4	3
	Individually but may consult with other students	1

In addition to the survey questions and answers in Table 1 that indicated a wide range of adaptability when implementing AlgebraByExample, the mid-year survey also indicated that six out of eight teachers did not enforce time limits with the assignments, the amount of time most students took to complete the assignments ranged from 10 to 30 minutes, three out of eight teachers gave students credit for the assignments, and four out of eight teachers reviewed the assignments after they had been given. The survey responses served as one indicator of the types of adaptability allowed in this partnership. The interview responses demonstrated why teachers felt this type of adaptability was valuable.

Brooke is one example of a teacher who, after working with the project for many years, understood how she could adapt the AlgebraByExample material to best fit her classroom. She said, “I’ve been using [AlgebraByExample materials] for the past four years and throughout the revisions, there’ve been some [that] are better than others. Some are a little bit too simple for some of my classes, so maybe I don’t use those assignments.” By having the flexibility to use the topics that she thought were most relevant to her students, she was able to adapt AlgebraByExample to best meet her classroom needs. Audrey also described different ways she used the assignments within a single class period:

> The way I use the lessons and the work that is presented with my classes, is […] as warm ups; I’ve used it as after-lesson checks to see if students understand; I’ve used it as review for tests – so I can maybe grab a couple of them that I haven’t gotten to finishing, and we’ll use those as practice for a test that might be coming up.

Again, the flexibility allowed with the AlgebraByExample partnership empowered Audrey to use the materials in a way that best suited student learning.

Will, who both used the materials as a teacher and was currently supervising other teachers at the time of the interview, described how his district valued professional discretion and decision making when it came to classroom implementations. The AlgebraByExample partnership allowed this flexibility among teachers, using voluntary participation as a model for implementation. Will also discussed how a group of teachers in his district felt that the AlgebraByExample material did not include enough open-ended problems. He stated:

> Both open ended questions and AlgebraByExample specifics – there seems to be a tension between those two things, and there seems to be a place for both. We've talked a bit, the teachers in my district that are here, we've talked a little bit about where it fits in, and when the AlgebraByExample work is useful, and when we think it needs to be more open ended in nature.

In this situation, teachers were able to use the materials flexibly in their classroom, as AlgebraByExample did not preclude using additional materials as the teachers saw fit. Because of this, the teachers continued to be invested in the benefits AlgebraByExample did provide. Will continued, "We think that probably all of us will start to use the example approach. We actually really enjoy it and like it. We're still trying to figure out exactly where it would fit in after the research is done." Because the design of the materials included flexible implementation uses, the adaptability of these materials to the classroom was a way in which the partnership focused on the needs of teachers.

Research has connected the success of an implementation with its fit with teachers' values, beliefs, and current practices (Forman et al., 2005). Many teachers cited examples of this type of fit with the AlgebraByExample materials. Teachers also discussed the ease with which the AlgebraByExample assignments could be used and the ways in which they were able to adapt the materials to meet their classroom needs. In these ways, the teacher-researcher partnership supported the implementation of new mathematics practices because it focused on the needs of the teachers. Adam summarized a well-researched view in his interview: “Changing classroom instruction is extremely difficult. The first thing that I think is important is having something that a teacher really believes is worth trying to do differently.”

The Evolution of the Partnership

As was noted earlier in this chapter, many challenges arose with the logistics of implementing a research study in classrooms. However, because SERP had a system set up for feedback and revision, these challenges were addressed and did not cause long-term disincentives towards the implementation. The ability of the partnership to evolve was the second feature that helped implementation become successful. Just as Brooke stated that the logistics were the toughest part of the implementation, she also noted:

> Overtime, [AlgebraByExample has] gotten to be a lot easier to do in the classroom. […] I think what has happened is it has evolved over time. We’ve sort of figured out a way to do things so that it isn’t so difficult for teachers.

Not only did she indicate that the implementation logistics became easier, she directly noted the importance both of the evolution of the project and of the collaboration around the response to identified needs. As two additional teachers with the initial concerns of logistical difficulty, Audrey and Isabel also noticed the implementation changes that occurred as the study progressed. Audrey noted that “as the study moves forward […] it won’t be [as] difficult” and there won’t be a “learning curve” for teachers as they partner with SERP in the future. Isabel also cited the change with such phrases as “since they’ve changed,” “the second iteration of SERP,” and “I was really thankful when we came back, and we started the next iteration," indicating that she continued to see progress that she appreciated in the way SERP dealt with logistics and implementation.

As a participant early in the research whose district took a break but came back to the partnership, Will discussed an anecdote from his experience, noting both the original challenges due to research and the way in which SERP evolved to address the concerns:

> When I was participating in the study before, I had students in […] one class [that] would be from both groups – the experimental group and the problem group – so everything ended up being a homework assignment, because there was logistically an issue with how to have the two groups in one place and facilitating that. So that's something that's good to see has changed. It seems logistically like that's moved forward, to a better model.

The ability for the SERP model to incorporate organizational growth is a key feature of the partnership that supported implementation. With many teachers citing logistical concerns during the first year, it can be assumed that these challenges would have negatively impacted implementation had they continued. However, with the ability of the partnership to evolve and address teachers' concerns, these challenges were addressed leading to a greater ability for the partnership model to affect instructional change.

Collaboration and Integration

The third and final identified feature of the teacher-researcher partnership that supported implementation of new mathematical practices was the multifaceted network of collaboration among teachers and researchers and integration of research and practice. With teachers having a strong support system to use the AlgebraByExample materials with ease and with the ability of the partnership to respond to changing classroom dynamics and teacher needs, the final step leading to the success of the implementation process was for teachers to have opportunities to participate in the cognitive work behind a research study and integrate their learning into their classrooms. It is important to note that this use of teacher inquiry models mathematical inquiry. As teachers grappled with research-based theory and implementation design, they expanded their own understanding of the use of the materials and associated practices. Communication, collaboration among peers and with researchers, professional learning, and taking ownership of the research theory were all ways in which data from this study suggested that the network of collaboration and integration was a key feature leading to a successful implementation.

Communication

Communication around logistics and expectations is a key component of any successful partnership, one that serves as the foundation for ongoing collaboration, and one that was identified in the mid-year survey data. Communication between the researchers and teachers about logistics ensured a successful research and implementation process. For example, while the mid-year survey was used to solicit feedback about AlgebraByExample materials and their use, it was also used to confirm that all participants had the materials that they needed; one section, in fact, was specifically titled "Check-ins & Reminders."

Within this section dedicated to communication about logistics, one question read, "I have received the revised Surveys 3 & 5, recycled the old ones, and placed the new ones in the expandable folders," with respondents able to select the following answers:

> Yes, someone from SERP did this during their visit […].
> Yes, I have received them, but have not replaced them yet.
> Yes, I have received them and replaced them in the expandbles [sic].
> I have not received any materials.
> Other

Another question asked participants to respond to “I have received the missing multiplying binomials worksheet for my PROBLEM based classes,” with either “Yes, I have the missing worksheet printed for my PB students,” or “I don't have the missing worksheet printed, please send.” These types of communication are a foundational component of ensuring a research partnership runs as smoothly as possible. Not only were teachers able to select the answer that best suited them, they also had an opportunity to personalize their responses back to the researchers. For example, when the mid-year survey asked for “ID codes of students who have entered my classroom since I administered the pretest,” some teachers answered with the exact codes, while one answered with “remind me later” and one answered with “emailed file with updates.” This type of dialogue indicated that the communication between teachers and researchers was comfortable, meaningful, and extended beyond the survey alone.

Communication was an important part of maintaining expectations as well. With research indicating the importance of shared expectations between teachers and researchers in a partnership (Baumfield & Butterworth, 2007), consistently revisiting those expectations can be an important feature leading to successful implementation. The mid-year survey served as one tool to keep expectations consistent. For example, one item on the survey stated, “I am planning to administer Survey 3 and Quarterly 2 to my classes by February 15th,” and asked teachers to respond with “Yes” or “Other” and a space to write a more complete answer. Another item on the survey asked teachers to “Please reflect on the ‘tentative’ assignment schedule you created at the start of the year. Please indicate how closely your usage aligns.”

Two out of eight teachers responded “almost exactly.” One teacher responded, “ I still am planning on using at least 35 assignments but which assignments I use will be different.” Half of the respondents answered, “The timing is different, but I still plan to use the same assignments,” and one teacher responded, “My first schedule never worked, but I am in the process of updating it and will send a copy.” This particular question encompassed communication about expectations as well as the adaptability of the assignments. Overall, communication about logistics and expectations was one aspect of the network of collaboration, an important feature of the partnership.

Collaboration Among Teachers and Researchers

The collaboration that influenced the successful implementation of new mathematical practices occurred not only among teachers and researchers but also extended to teacher collaborations amongst themselves, both in a formal working group setting as well as informally in their school buildings. First and foremost, the collaboration among teachers and researchers was an important component that supported the implementation of the new practices. Interviewees specifically discussed these collaborations with researchers. The importance of this collaboration towards the goal of implementation parallels the findings of the first research question, where teachers' identified their role as a collaborator in the research process. In this case, interviewees talked about the importance of the direct interaction with the researchers themselves. This direct interaction was one step towards supporting successful implementation.

As a leader, Will noticed, “specific teachers have been able to ask questions of researchers, and they've been able to ask the questions that are really important to them and where they kind of see this going in their own classrooms.” By specifically referencing the direct contact with researchers, Will highlighted one important way that researchers and teachers are connected throughout this process. This statement indicated an ability for the research to become more personal to teachers, as the answers they were receiving were tailored specifically to their needs. As incoming participants to the working group, both Marco and Kate were excited to have connections with the researchers personally. Marco stated that he has been "deeply interested in the research surrounding worked examples and specifically interested in the publications of the two researchers we are working with for probably four or five years." Kate indicated that she was looking forward to communication with the researchers as she began implementing the project for the first time.

The collaboration that occurred among teachers and their peers was also an important aspect of the partnership. Some of the opportunities for collaboration were planned – the working group meetings for example – and some were unplanned – teacher conversations with colleagues as a different example. However, these conversations were all fueled by the research partnership, and teachers cited collaboration as a key feature during their interviews.

When thinking about collaboration opportunities, both Brooke and Isabel referenced the number of teachers that have participated in the partnership from their buildings. To Will, this type of participation was important, because the participating teachers are able to talk "a little bit about where [AlgebraByExample] fits in" with their existing curriculum. The participating teachers also collaborated or advised colleagues who did not participate in the partnership. When Brooke was describing how change occurred in her school, she mentioned how non-participating teachers "start hearing about" the AlgebraByExample benefits. She also described how other teachers may be seeking resources on a particular mathematics topic, and "we'll look at the [AlgebraByExample] website, and pull something up that they can use." Brooke valued this type of collaboration and attributed success of implementation to informal conversations such as these. Will stated that teachers in his district used more formal collaborations to discuss future use of AlgebraByExample materials. He said that to make future decisions, "we would use individual teachers [and] their experiences." Finally, Marco clearly valued the collaboration that occurred at the working group, citing the "people who love to talk" about research and education. Collaboration around the materials and practices among researchers, teachers, and their peers was another way in which the partnership supported the implementation of AlgebraByExample.

Professional Learning

The next aspect of the network of collaboration leading to full integration of research-based practices was the opportunity for professional learning. Just as teachers identified themselves as collaborators in research question one, teachers also identified themselves as learners in the partnership, and research supports the importance of professional learning in implementation work. As stated earlier in the paper, Conway et al. (2014) claimed research participation as a meaningful professional learning experience specifically because of the connections that are drawn between experience and theory. Isabel exemplified making these connections when she stated, "I've learned, and my colleagues […] have also learned that through error analysis and through formative assessment […] students learn a great deal." Isabel was able to learn about the research behind example-based learning, apply it to her classroom, and see student results

– a perfect connection between experience and theory. Adam discussed his learning of "how to help students who weren't necessarily traditionally successful in algebra," while Will highlighted his interest in the specific research used to develop AlgebraByExample. Connected to the importance of collaboration, Marco mentioned how the working group contributed to his learning by connecting people who love to talk about "experimental protocol" and "teaching." This type of professional learning was embedded within the collaborative structure of the teacher-researcher partnership, specifically allowing teachers to draw connections between research and their classrooms. This type of learning specifically enabled teachers to wrestle with how learning theory connected to the mathematical practices they enacted in their classroom, and ultimately served as another step on the continuum leading to the full integration and implementation of the AlgebraByExample materials and practices.

Ownership and Integration of Research

Teachers involved in the collaborative structures of the research partnership had opportunities for communication about logistics and expectations, collaboration with researchers and teachers, and professional learning. Together, these opportunities led to an eventual sense of ownership and the ability to integrate research-based ideas naturally into their classrooms. Implementation researchers, such as Coburn (2003), Evans et al. (2000), Ormel et al. (2012), and Powers et al. (2005), all acknowledged the importance of teacher ownership in successful implementations. As stated earlier in this chapter, teachers working in the AlgebraByExample partnership viewed themselves as collaborators, which led to a sense of ownership of the project.

Examples of ownership included David's description of the working group's responsibility to "create and edit the assignments," as well as Isabel's and Brooke's (among others) use of the pronoun *we* when describing the data analysis, reflection and revision, and problem solving processes used to develop the current version of AlgebraByExample. Marco also observed that the teachers "feel invested in […] adding to the store of human knowledge about teaching and learning." Ownership was an important component of the full implementation of the new mathematical practices, because the more ownership of any reform shifts to teachers, the more likely it is to create lasting change (Coburn, 2003). The collaboration and opportunities to become owners of the research process helped teachers integrate the desired mathematical practices into their classroom. However, the benefits of collaboration went both ways, affecting both teachers and researchers alike. Just as the teachers were impacted by the research process, the researchers' work was affected by the realities of the classroom.

For example, Marco noted, "SERP is a pretty unique attempt to research new ways of teaching and instruction in actual classrooms instead of in laboratory settings, and over longer periods of time than a typical study will produce." He went on to describe "a bewildering array" of information about how to teach, and how that in isolation, most of this information "doesn't really provide answers in an actionable way to teachers." Marco used the metaphor of baking a cake to describe the importance of the way SERP integrates teaching and research:

> If you think about trying to make a better math class as analogous to trying to bake a better cake, you've got some researchers who are researching what is the best flour to use. And then you have other researchers who are working on what's the best baking powder or leavening agent to use. Unfortunately, even if you get the perfect flour, if you completely forget the eggs, it doesn't really matter – your cake is going to stink. And so

> only when you do a study that combines all of the ingredients together – which means it can't be a single intervention that took place on one day and was measured the next day; it has to include all of the variables: classroom management, your lessons, your assessments, everything that goes into a class – the only way you can really see if you baked a better cake is to try your intervention in a realistic setting over the time frame of an entire year. Otherwise you are just measuring one ingredient, like that chapter, but not the class. I think that's pretty unique. There aren't very many examples that I know of where researchers imbed themselves in a class over that time scale.

The ability of the researchers to learn from the teachers and the teachers to learn from the researchers led to a truly integrated research approach. With this type of collaborative, integrated work, teachers were able to utilize research theory in ways that had been developed responsively to their needs. Because of this responsiveness and iterative development, the teachers ultimately integrated the implementation with their classroom routines.

This aspect of full implementation was evidenced by the amount of research-based ideas teachers integrated into their conversations about their classrooms. Teachers frequently discussed misconceptions and worked examples – key research-based theories upon which AlgebraByExample was built – often paraphrasing research as they described their classroom experiences. This was apparent in both the interview and survey data.

Many interview subjects integrated research theory and personal experience when discussing the AlgebraByExample project aim – ending misconceptions in algebra. Six interviewees described the ways in which the research and student experience were intertwined. Many included a paraphrased analysis of the cognitive dissonance their students experienced when completing the worked examples. For example, Brooke discussed the ways her students were forced to confront their misconceptions as per the design of the study:

> It really works at some of these stubborn misconceptions that [students] have, this idea that they're so convinced that they're right, that when you show them a problem that is correctly done, and they think "Wait a minute, that's not correctly done," they will try to point to you "hey, there is something wrong with this piece of paper here, this isn't right," and you just have to keep saying, "no, that is correctly done, what you have to work on is what is it you're not seeing in this problem," so I think its been really helpful for the classroom…

She later continued:

> [AlgebraByExample materials] tend to be really helpful when kids have this sort of stubborn misconception of this idea, for example of slope, that it isn't rise over run, but that it's run over rise. And so when kids see problems that are worked incorrectly and told that this is an incorrect problem, they actually have to go figure out what's wrong here.

Her ability to articulate the experience of cognitive dissonance in the classroom indicated a connection between her learning of the research on misconceptions and her real-world experiences in the classroom. While in some way it may appear as her statement about misconceptions is talking about a mechanism that makes these materials work well, the important part of this finding is that the teachers are the ones that are able to articulate and incorporate these research-based ideas into their classroom experiences.

Similarly, Audrey said that AlgebraByExample gave students "something to talk about that really targets the misconceptions…." She described how the misconceptions were made personal by the worked examples, and how her students experienced cognitive dissonance much like Brooke described. Audrey stated:

> What the AlgebraByExample writers have done is put in [students'] very common mistakes, common misconceptions, things that students frequently […] do wrong. […] What they've done is by putting in these incorrect examples and telling the students this is incorrect, is force [the students] to say, "That's what I do. What should I do then, if I'm doing the same thing as this boy in this problem? What's wrong with that?" And if they're not sure, the fact that they have a partner or group that they can confer with, and ask "well, that is what I've done, and that is how come I got my homework wrong last night. What should he be doing?"

> And it starts that conversation, and then the guided questions are done in a way where it will say, you know, "this student did something wrong at the arrow. What's wrong with the step at the arrow?" So it gives students an even bigger clue of where that mistake is coming, and where they have to look […]. It is really good because [the writers] are targeting not just, you know, "they added 6 and 7 and wrote the wrong sum," they are targeting the mistakes that students make and forcing them to see that it isn't right.

Audrey also described the importance of incorrect examples, which parallels research in worked examples as well. Audrey explained, "The incorrect examples are actually sometimes the ones that really are better in some ways [as] a learning tool. The incorrect examples are often the best learning tool."

Isabel also repeated a very similar narrative to that of Brooke and Audrey as she described how students benefited from the worked example problems. Isabel described:

> I believe [AlgebraByExample] is very helpful because students don't realize that there are a number of misconceptions that they have in algebra. So when they look at correct examples and are asked to figure out from this step to this step, or wherever this arrow indicates, what is it that the students did correctly or, you know, in an incorrect example from this step to this step, what was the misconception here or what did the student forget to do in this step? When they actually have to have a conversation and determine, "oh so this student forgot to multiply the other side by that same constant," or "this student divided everything in the equation except for this term," it kind of validates that student's understanding: "oh so they have that same misunderstanding that I have." […] I just find it a very good learning tool for students, to kind of figure out a misconception and then use that same problem that's next to it to work through it and make sure that they don't make that same mistake. So I think [AlgebraByExample] is an important thing for students to have.

Similar integration of research on misconceptions and worked example with classroom practices was noted in the end-of-year survey data. When asked, "What did you like best about using the EXAMPLE based materials in your classroom this year?" some teachers responded with research-based answers. Andy, for example, answered, "I think that learning by reviewing worked problems, is a great way to learn." Brooke also noted, "I continue to like how students are forced to confront their misconceptions." Kate went into more detail, answering with:

> I loved that it reminded the students about how to solve the problems without me reteaching. It also cleared up the misconceptions. Sometimes students would be confused why the problem was solved wrong, then it would lead to a great discussion and their misconceptions would be cleared up! Love this problem.

These teachers identified worked examples as a strategic method to confront misconceptions, which comes from researched theories, while also connecting it to their classroom experiences with students.

As a leader, Adam described the experiences of teachers and students and made parallels to his knowledge of the research as well. Adam stated:

> I've been a long time supporter of the concept of showing counter examples. I also know a lot about the research of students who have misconceptions in mathematics and how that can lead to problems. And in my own teaching experience, I know that often times, as teachers, we would teach right up to the bell because we were so pressed for time. We would send students home to do the assignments. The students would go home thinking that they understood. And then by the time they got home, they realize they didn't understand. And so what oftentimes would happen is they would do the problems inaccurately; they would come back to class; we would go over the homework, often times fixing those problems. But what would happen is they would do a few of the problems correctly, but then three weeks later when they would see it on an exam, the mind would revert back to the way they did [them] more often than not, which was the incorrect way. And so, I feel that exposing these misconceptions and the common mistakes that kids make is an opportunity for kids to begin doing the math correctly the first time that they do it, so that they're not unlearning or having to relearn topics.

In this description, Adam connected the research of misconceptions and worked examples to his own personal experience, identifying the importance of confronting misconceptions early. He also demonstrated knowledge of successful research around misconceptions.

In these previous cases, experienced teachers connected the research on misconceptions to the AlgebraByExample material and their own experiences. However, even the two new teachers articulated the important connections between the research and their future work. Marco demonstrated his knowledge of worked example research and its ability to focus on misconception as he stated, “So looking at wrong answers gives students a chance. It prompts students to focus their attention specifically on the feature that is most difficult or that might cause a problem in the future.” Kate described more of a personal experience she has had with her students and misconceptions and then connected that to her future use of the AlgebraByExample problems. She stated:

> I think it is really helpful for [students] to see misconceptions in their work. Just as a teacher, like every day when we do warm ups, I have students come up, and I see them do mistakes. And a lot of the shy students, they don’t want to go up because they’ll think they’ll make mistakes, and I’m like, “No, go up. Show us what you did.” And if there are mistakes, usually you know, if they don’t see it right away, there’s other students that you know [say], “oh you need to do this instead.” And then they’re like, “oh, that’s what I did wrong.” So it’s just getting them over that fear of like “I can’t make a mistake.” […] Having [AlgebraByExample] in front of them, they can see, “oh, I’m not the only one that makes those mistakes,” or say, “oh, I didn’t know you could make that mistake” for the ones that always get it right too. So I think [AlgebraByExample] is really important [because] it clears up their misconceptions before they keep moving on.

Kate, Marco, Adam, Isabel, Audrey, and Brooke all articulated ways in which they integrated the research behind AlgebraByExample into their classrooms. They were able to discuss research theory within the context of their experiences. With researchers being responsive to teacher needs and teachers learning from researchers’ experiences, they formed an integrated partnership that led to the implementation of mathematical practices that were both practical and research-based. The close-knit collaboration, communication, and learning opportunities all led to a successful implementation of research-based practices in the classrooms.

Future Use and Instructional Change

The interview, survey, and observation data all helped to answer the three research questions set out at the beginning of this analysis. While no research question directly pursued the long-term implications of the research partnership, some of the survey and interview data indicated that many teachers did believe the practices would continue in their classroom.

When asked on the end-of-year survey if they were "likely to use AlgebraByExample assignments (or workbooks) in your classroom or district next year," 10 out of 12 teachers responded with an answer of "yes," while the remaining two teachers indicated that they would use the concepts but create their own material. Of the mathematics coordinators, three out of four indicated "Yes, I am already discussing their use with others in my district," as their response. In the interview data, Brooke volunteered the information that when "working on quadratic or binomial" units, she used the AlgebraByExample materials "with classes, even when we aren't doing the study." With further prodding, Brooke stated that "I would definitely use them" in the future.

The future use of AlgebraByExample materials derived from the partnership model explained in this paper could also be anticipated through teachers' continued discussion of the project into the future. Audrey "hope[d] that we are moving to having some sort of resources available to teachers to use AlgebraByExample work," while Isabel explained that her colleagues have "start[ed] using error analysis in their classrooms." Perhaps Will's district provided the most clear indication of use of the new practices in mathematics teachers' classrooms beyond the scope of the research partnership, as he explained how "we do have some teachers that have participated before who are no longer participating in the research because they see such value in using the examples, that that's what they use in the[ir] class." A full discussion of how the research-partnership model can impact long-term classroom change will be left for another study, but ultimately, Adam summed up the importance of the teacher-researcher partnership when he said, "I think there is an opportunity to impact the way teachers teach."

CHAPTER 5

DISCUSSION

The purpose of this study was to investigate the relationship between a teacher-researcher partnership and the implementation of new mathematics practices in the classroom. Given continued reports of mathematics achievement data showing stagnant growth and documented performance gaps among students of different demographic backgrounds (The Nation's Report Card, 2015) as well as inconsistency in the implementation of new instructional practices in mathematics classrooms despite a variety of efforts (Borman, 2009; Burns & Ysseldyke, 2009; Confrey & Stohl, 2004; McKinney et al., 2009; Star et al., 2015), educators from all fields continue to search for strategies to implement new practices and increase students' mathematics achievement.

Based on the importance of considering the role of the teacher in classroom reform models, this study investigated the teacher-researcher partnership as a way to acknowledge the complex relationship among teacher inquiry, teacher beliefs and attitudes, teacher knowledge, professional development, and instructional practices in a mathematics classroom. Building off of prior studies of implementation research and change theory, this study found that a teacher-researcher partnership has great potential to impact the implementation of research-based practices in the classroom in which multiple complex factors can be managed to contribute to instructional change. To understand this potential, the following three questions were asked, with results discussed below:

a. How do mathematics teachers view their own participation in a teacher-researcher partnership?

b. How does the implementation of a new mathematics practice differ between teachers who participate in a teacher-researcher partnership and those who do not?

c. What features of a teacher-researcher partnership support the implementation of new practices in mathematics classrooms?

Teachers' Views of their Participation

Results indicated that mathematics teachers viewed their own participation in a teacher-researcher partnership from many perspectives including that of a collaborator, a learner, and as an agent of change. The complexity of teachers' self-perception is an important feature to note within the teacher-researcher partnership, as each category of perception is interrelated and builds upon one another. Additionally, while some of these roles may seem contradictory – both being a collaborator with the implementation process as well as being a learner throughout the process – teachers navigated these roles naturally throughout the project.

To date, little research has investigated the ways in which teachers participating in a research partnership view their role, yet this notion could impact implementation success. With implementation research indicating the importance of collaboration (Opfer & Pedder, 2011) and ownership (Coburn, 2003), the fact that teachers who participated in the teacher-researcher partnership embraced their role as both a collaborator and as an owner is one indication of why this type of partnership led to greater success in implementation for those who interacted closely with researchers. Both collaboration around and ownership of instructional ideas and strategies lead to feelings of empowerment by teachers, as indicated by the investment and excitement communicated during the interview process. With meaningful instructional change falling on the shoulders' of teachers, this feeling of empowerment coupled with the knowledge of research is what begins to sow meaningful implementation. Ownership and collaboration lead to teachers having a voice in the change process, which is a critical component of successful implementation (Evans et al., 2000). Participating in the creation of knowledge embeds teachers directly in inquiry, which also is a driving component of instructional change (Cochran-Smith &Lytle, 2009).

Conway et al. (2014) found that teachers participating in research within the field of music education found those experiences to be meaningful professional learning experiences. This study confirmed a similar effect for mathematics teachers. These teachers learned about formative assessment, student learning, instructional strategies, algebra instruction, addressing misconceptions, and research theory, among many other topics. Not only does increased learning affect teachers' abilities to implement high cognitive demand tasks (Charalambous, 2012; Hill & Charalambous, 2012), the openness to learning is one characteristics of a growth mindset for teachers (Dweck, 2010). Growth mindset research has shown that teachers with these characteristics are more likely to create lasting change in their classrooms. All of these factors coupled together demonstrate how teachers' self-perception as a learner also influences their implementation success.

Finally, by seeing themselves as an agent of change, teachers in this study demonstrated a conceptual change model that paralleled the results of the Cognitive–Affective Model of Conceptual Change (CAMCC) (Gregoire, 2003). While the CAMCC set out to describe a model of conceptual change with no specific notion of a teacher-researcher partnership, the model concluded with a teacher thoughtfully engaging with an implementation. As teachers saw themselves as agents of change in the research partnership, one key feature of the implementation success was the way in which they could thoughtfully engage with the implementation. Gregoire (2003) asserted that "teacher educators, policymakers, and researchers" alike should all "examine ways to increase teachers' ability to reflect upon and successfully implement advocated reforms" (p. 172), going on to suggest that educational leaders must find ways to make this possible for teachers. Based on the results of this study, a teacher-researcher partnership is one way to make thoughtful engagement in the change process possible.

Differences in Implementation Based on Interaction with Researchers

After understanding how teachers participating in the partnership viewed their own participation, this study investigated if differences in implementation existed between teachers who engaged directly with researchers compared to those who did not. This question attempted to understand the value for teachers of direct interactions with the researchers and with the research process based on the importance of teacher inquiry in instructional change processes. An analysis of the different ways in which teachers participating in the partnership at different levels implemented the new mathematics practice indicated that many implementation differences did indeed exist. Such differences included the amount of time spent using the AlgebraByExample materials, students' interactions with the materials, the focus of classroom discussions, the use of group work, and the amount of student-centered classroom activities. These differences can be characterized such that teachers who interacted with the research partnership extensively embraced the materials, the intent of the materials, and the connected mathematical practices more holistically than those who did not have the same experiences with the research process. It is important to note that these differences cannot be attributed to differences in belief systems or knowledge of the AlgebraByExample materials, as all teachers in the study reported similar perceived benefits of the new mathematics practice and a positive attitude towards the materials. Additionally, all teachers were able to articulate the research-based theory behind the new mathematics practices, and all teachers self reported similar ratios of lecture-to-practice time spent in class.

What these differences do indicate is that something about the interactions between the teachers and the researchers or the involvement of the teachers in the research process drives teachers to implement the new practices more universally. As previously discussed, the Cognitive–Affective Model of Conceptual Change proposed by Gregoire (2003) values thoughtful engagement. This type of thoughtful engagement could explain the differences between groups in this study, as the very nature of the interactions with researchers caused teachers to reflect on their learning and on the implementation processes, which has been associated with positive implementation outcomes (Gregoire, 2003). These results are also consistent with the inquiry stance theory proposed by Cochran-Smith and Lytle (2009). Inquiry stance poses that by participating in classroom inquiry, teachers will be part of the knowledge-creation process, and that through this process, continual reflection, collaboration, and questioning will drive instructional change. Prior research has shown that the use of teacher inquiry in mathematics classrooms can be a powerful form of professional development and learning because of its parallel structure to mathematics inquiry. Teachers engaged in inquiry have been able to better integrate inquiry in their own mathematics classrooms (Jao & McDougall, 2015; Lotter, Yow, & Peters, 2014). This study showed that teachers involved in the knowledge-creation process by participating in the research along side academic researchers did show more of a proclivity towards instructional change. Knowing additionally that prior studies have found inconsistent implementation of new instructional practices in mathematics classrooms (McKinney et al., 2009; Star et al., 2015; Vetter, 2012; Wilson, 2003), the consistent results of implementation success among teachers who have participated in the research process is noteworthy.

Many recent studies have begun to tout the benefits of teacher-researcher partnerships (Coburn & Stein, 2010; Kochanek, Scholz, & Garcia, 2015; Penuel, Allen, Coburn, & Farrell, 2015), but the unique structure of the AlgebraByExample framework allowed for an examination of classroom practices based on different types of interactions with researchers. As mentioned earlier in this paper, the Connected Mathematics Project (CMP) used a teacher-researcher partnership model in developing a widely-used mathematics curriculum that continues to be refined over time. While published writing about their partnership does not exist, one of the original designers of the project, Betty Phillips acknowledged that teachers who participated in the partnership were more successful at implementing the intended curriculum (B. Phillips, personal communication, January 21, 2016). This study provides empirical evidence of this assumption. Betty stated that the teachers that continue to work with researchers both implemented the materials better in the classroom as well as grew as learners. As proposed with the inquiry stance theory and the CAMCC model of change, this study has demonstrated that teachers interacting with the research process grapple with cognitive theory as it applies to their classroom and ultimately embrace new instructional practices more so than teachers who are only asked to use some new materials.

Supportive Features

In the interest of future replication or dissecting critical components of the AlgebraByExample partnership, the features of the teacher-researcher partnership that supported the implementation of new practices in mathematics classrooms were investigated. Findings indicated that a focus on the teacher, the evolution of the partnership, and a network of collaboration and integration all contributed to the successful implementation. All of these features emerged as consistent trends from the interview and/or survey data. In some cases, these features paralleled prior research, and in other cases these trends presented a new lens upon which to examine teacher-researcher partnerships.

Extensive research has documented the importance of the role of the teacher when considering instructional change models (Desimone et al., 2005; Jepsen, 2005; Penuel et al., 2011; RAND, 2003; Slavin & Lake, 2008). As discussed earlier in this paper, the role of the teacher must include a consideration of their attitudes, beliefs, and behaviors, and is critical because teachers are the ones charged with actually enacting any change (Burns and Ysseldyke, 2009). Data from this study suggested that the AlgebraByExample teacher-researcher partnership was successful in part because of its ability to focus on the role of the teacher, specifically through attending to the teachers' desires for change that fit within their current classroom structures, materials that were easy to implement, and practices that were able to be adapted to their unique classroom contexts. Forman et al. (2005) explained how implementation is most likely to be successful if the new practice is not too different from current practice. AlgebraByExample had many features that teachers found comfortable to use because it matched but extended their current practices or it matched their belief system.

In addressing teacher attitudes and beliefs, the AlgebraByExample partnership model included beginning with teachers that were open to change and then relied on teacher-to-teacher collaboration and discussion to disseminate change on a wider-scale. As an example of the supportive research for this type of change model, Dweck (2010) discussed the importance of a growth mindset for changing instructional practices. Her research on growth mind-set for teachers indicated that teachers with growth mind-sets are more open to professional learning and close achievement gaps faster. In the interviews, three teachers talked about their own mindsets in ways that corresponded to Dweck's research. These teachers identified being willing to try new things and always learning as characteristics of themselves as educators. Brooke, for example, stated:

> I'm always willing to try new things, and so this idea that 'there is only one way to do something, and that's the way I've done it for 15 years' is just silly. So […] when we started doing things differently, I just sort of plunged into it.

She later continued, "I think that we all have to always be wiling to try new things and do things differently. Otherwise, you know, we get sort of stale, and you become that teacher that the kids can't stand."

Similarly, Will, as a teacher leader, directly said, "I think that in general our teachers are very open to trying new things." Kate also identified these same characteristics about herself, stating "I'm pretty flexible […] and being a teacher, you have to try new things in order to see what works best for your students. So, you've always got to learn." This interview data demonstrated how teachers' beliefs and attitudes corresponded to research on growth mind-set.

Guskey (2002) and Çetinkaya (2012) both acknowledged the difficulty of changing teacher beliefs and attitudes, and teachers in this study discussed how the best way to change the attitudes of some of their more resistant peers was through constant discussion and modeling of successful practices. This set the stage for school-wide change that was repetitive and iterative, which is consistent with Opfer & Pedder's (2011) assertion that change does not follow a linear progression. The AlgebraByExample partnership was set up to be responsive, where researchers and teachers continued to learn from each other, and included multiple aspects of collaboration and integration that also allowed for a non-linear, but more realistic, model of change.

Interview data supported the notion of a repetitive and iterative process of change. Brooke, for example, discussed how change occurred at her school. It is important to remember that Brooke herself exhibited characteristics of a growth mind-set, but she acknowledged, "I think we had teachers who were resistant to change [and] teachers who were not resistant to change." She continued, "We've had teachers who, over time, have evolved. After a few people do something, slowly [other teachers] start hearing about things, then they start trying them in the classroom…" In this statement, Brooke acknowledged that some teachers in her school may not share her growth mind-set, but she also recognized they ability for their views to evolve. The change process, from her eyes, included having some teachers begin to implement a new practice, and as they found success and shared their success stories with their colleagues, more resistant teachers started to become more open to trying the new practice as well. Similarly, Audrey discussed a "learning curve" among teachers when implementing the new practice. This indicated both that learning is a continuous process but also that resistant teachers will indeed learn, albeit at a potentially slower pace. Audrey held the notion that all teachers can change in ways that support the new practice.

The nature of long-term, collective change relies on teachers sharing, collaborating, and encouraging each other. Just as Brooke indicated that teachers learned from hearing things from others, Isabel also discussed how the learning process associated with the AlgebraByExample partnership extended to all members of her team. She stated, "My colleagues […], everyone [has] also learned that through [the AlgebraByExample instructional practices], students learn a great deal." Kate, one of the new-to-the-project teachers, indicated that her own participation was based on a recommendation from her mathematics coach, after he had participated himself.

This entire network of collaboration and integration included communication, collaboration among both teacher groups and researcher groups, and professional learning. Baumfield and Butterworth (2007) discussed the importance of communication along with mutual expectations and mutual goals as a key factor in implementing a new practice with teachers, and this study found that communication was a key feature of success here as well. Finally, as already discussed, teacher ownership of the desired implementation was an important result of collaboration among teachers and researchers as were professional learning opportunities, both of which were key features in the collaborative model as well.

Perhaps more interesting are the features of the partnership that have been less researched; these ideas were all discussed by teachers themselves and identified as important features of the partnership by the researcher. The ability of the AlgebraByExample partnership to evolve was one mentioned frequently by teachers; each teacher indicated an appreciation and the need of the partnership to evolve. Some of the changes occurred within logistical considerations, and other changes occurred within the design of the study. Change in any research study is to be expected, and not unusual within a research partnership as well. Penuel et al. (2011) described an iterative and collaborative design used by the partnership between the Middle School Mathematics and the Institutional Setting of Teaching (MIST) project at Vanderbilt University. In this example, the district was the driving decision-making force from year-to-year, and after careful consideration of first-year results, researchers made recommendations to improve the research model. The AlgebraByExample partnership, however, generally saw change being driven by feedback provided from the teachers to the researchers. Research on the value of the evolution of a partnership has begun in partnerships outside of education, in the field of community support for example (Sorensen & Lawson, 2012). Most importantly, however, was not necessarily the fact that the partnership evolved over time, but that the teachers specifically saw *value* in that change over time. Coming on the heels of a documented potential for negative views of teacher-researcher interactions (Groth & Bergner, 2007), the fact that teachers found this evolution noteworthy is noteworthy in and of itself. To the teachers in this partnership, the evolution represented a true indication of collaboration where researchers listened and responded to the needs of the teachers. This indication of valuable collaboration is consistent with the value

Ormel et al. (2012) found in multiple instances of collaboration. Even when all other features differed in a review of numerous research-partnerships, close collaboration was a feature in each (Ormel et al., 2012). Only with close collaboration, intentional listening, and best-intent of all stakeholders can a research-partnership truly evolve. This study is one such example.

While collaboration among teachers and researchers was an expected feature of a successful teacher-researcher partnership, perhaps a more unexpected feature was the collaborative opportunities among teachers that arose from the partnership as well. Similar to all other findings, this feature was mentioned directly by teachers in interview and survey data. Teachers discussed the collaboration that took place among their peers at the working group meetings as well as collaboration that occurred back at their home schools, both with others participating in the research study as well as those who were not. While collaboration research in general is a large and diverse area of focus for education researchers, the connection on how teacher-researcher partnerships support teacher-to-teacher collaboration is scant. Penuel et al. (2011) began to surface the impact that research-partnerships can have on school structures that support ongoing learning, collaborative conversations about teaching and learning, being one of those structures. Teachers in this research partnership definitely highlighted teacher-to-teacher collaboration as one feature of their experiences.

As the research-practice gap has occasionally highlighted, communication among teachers and researchers has not always historically been prevalent. Therefore it is perhaps no coincidence that two final features of the research-partnership discussed by teachers are often overlooked within research itself: the ease of implementation and the adaptability of new strategies. Increased accountability measures, high-stakes testing, decreased budgets, and increased student need places high levels of stress on teachers increasing each year. Teachers within this study unanimously cited time management as their biggest challenge. It comes as no surprise, then, that teachers also appreciated many factors of the research-partnership that led to easy use of new ideas and materials. This particular partnership had a theoretical model that was easy to implement (worksheet-based worked-example problems that spawned discussion and required little-to-no professional development time) as well as researchers that provided materials and supports to the best of their abilities (copies and research-specific forms all delivered to the teachers ready to use). The ease of implementation was valued by teachers and should be considered as an important feature of the partnership.

Similarly, with increased outside demands and attempts to automatize instruction, teachers cling to the need for professional autonomy. In this way, many teachers cited the adaptability of the materials used in the partnership as a meaningful approach to using the materials. In some ways, teachers being able to adapt the materials to their classroom as best they see fit flies in the face of fidelity research. In a fidelity literature review, O'Donnell (2008) defined fidelity as "the determination of how well an intervention is implemented in comparison with the original program design during an efficacy and/or effectiveness study" (p. 33). The key component of *comparison* becomes more difficult as each teacher does actually use materials and strategies in a different way. However, based on individual classroom culture and complexities, teacher adaption with intense cognitive support may actually lead to more consistent success in implementing new mathematics instructional practices. The desire for adaptability is supported by the theories of teacher inquiry as well. The inquiry stance (Cochran-Smith & Lytle, 2009) values the cognitive process that occurs when teachers engage in meaningful learning, exploration, and application to their classrooms. Recently Kochanek et al. (2015) claimed, "It has been suggested that practitioner involvement in research can build capacity to incorporate systematic inquiry into decision-making processes within practitioner communities" (p. 23). Based on the results of this study, these decision-making processes may apply to classroom practices as well.

Overall, the features of the teacher-researcher partnership that supported the implementation of new mathematical practices were consistent with prior research. Specifically, a focus on the teacher, the evolution of the partnership, and a network of collaboration and integration were all a part of a partnership model that led to successful implementation.

Closing the Research-Practice Gap

A plethora of research evidence exists about the research-practice gap and potential benefits for closing the gap on student achievement and instructional quality (Cooper, 2007; Smith, 2000; Spencer et al., 2007). This study indicated that it is not enough to just have researchers give teachers tools or information (as was the case for teachers not involved in the working group), but instead it is critical for researchers and teachers to work collaboratively together throughout the whole process. These findings are consistent with Penuel, Allen, Coburn, and Farrell (2015) who stated, "The partnerships we have studied teach us that researchers and practitioners working in partnership are engaged in processes of collaboration and exchange that are both messier and potentially more transformative than the one-way translation of knowledge of research into practice" (p. 183). Kochanek, Scholz, and Garcia (2015) came to an identical conclusion, stating, "Emerging experiences suggest that collaborative research partnerships can benefit both research and practice. First, including practitioners on a research team can bridge the research-practice divide, increasing the likelihood that research findings will be applied to practice" (p. 23). In defiance of the common trends that research rarely informs practice and practice rarely informs research (Spencer et al., 2012), this partnership led to learning and growing occurring among both researchers and teachers. In this study, it was the direct interactions among researchers and teachers, the ways in which researchers responded to teacher needs, and the ability for teachers to learn, utilize, and communication about the research-based theory that indicated the research-practice gap was closing in ways that affected implementation. Researchers continued to learn from teachers and adapted their methods as the project went along, and teachers learned from researchers in ways that led to integrated research-based practices into their classrooms and ultimately meaningful change. The research-practice gap is a well-known divide among researchers and teachers who are centered on different educational goals. However, seeing the difference that the interaction between researchers and teachers can create in classroom implementation drives home the importance in considering future work among all participating parties. Combining the knowledge and experiences of teachers and researchers has the potential to lead to more meaningful implementations of research-based practices.

The AlgebraByExample teacher-researcher partnership brought together multiple, complex features of mathematics instruction, classroom and teacher variables, and research theory in ways that supported the implementation of new ideas. Teachers who engaged most directly with the researchers were much more likely to embrace the new ideas and enact new mathematical practices in their classrooms. In ongoing and consistent work with research-partnerships, Penuel et al. (2015) called for "an alternate conceptual framework that more adequately accounts for the complex and difficult challenges researchers and practitioners face together, if research is to inform educational improvement" (p. 183). This study on the AlgebraByExample partnership attempts to add to a new conceptual framework about how researchers and teachers interact and how instructional change is brought into mathematics classrooms.

Implications

Many attempts to implement new, research-based practices in classrooms are inconsistent at best and ineffective at worst (Boaler & Staples, 2008; Gregoire, 2003; Hiebert & Stigler, 2000; Huffman et al., 2008; Leikin & Levav-Waynberg, 2007; McKinney et al., 2009). As Gregoire (2003) was quoted earlier in this paper, "lasting belief change cannot occur without teachers' systematically processing reform messages" (p. 168). If one of the reasons that prior attempts to implement new practices consistently has failed has been the lack of attention to the need for teachers to grapple with the practices cognitively, to take ownership of these practices, and to be part of the change process, then teacher-researcher partnerships may serve as a model combining multiple features that support implementation success. By focusing on the teacher's role, by both planning to address implementation challenges as well as creating a structure that can evolve, and by connecting researchers and teachers through meaningful collaborative relationships, more efforts to engage in teacher-researchers partnerships may be able to change the landscape of mathematics reform efforts.

This study has implications for teachers and researchers, as well as administrators, policy makers, and funding agencies. Researchers interested in impacting classroom outcomes should consider using a similar model of interacting and learning from teachers. Teachers, who have been known to be skeptical of impractical, laboratory-based research in the past, could learn about theory and practice in ways that were expressed by the teachers who participated in this partnership. Finally, administrators often have a key role in supporting the professional learning and implementation efforts in a school district. Armed with findings from this study, administrators would be advised to consider reaching out to find research partnerships as a means to improve classroom instruction and teacher learning.

Implications for both policy makers and funding agencies include being more critical of education research or policy proposals, unless great care has been taken to ensure the connection between the research and the application. Knowledge of the importance of researchers and teachers working together is not new, but has rarely been done well: "despite significant federal investments in the production of high-quality education research, the direct use of that research in policy and practice is not evident" (Kochanek et al., 2015, p. 1). Kochanek et al. (2015) go on to describe one attempt at a research-partnership model – Regional Educational Laboratories (RELs). Whitehurst (2010) discusses RELs from a historical perspective, and points out many challenges that have prevented widespread success from this model. He also points out that many of the challenges are starting to shift towards a more productive model, including more access to high quality research, national priorities more focused on education reform, and a more thorough independent review process. Whitehurst (2010) and Kochanek et al. (2015)

indicate optimism towards the future of RELs in the future, with Whitehurst (2010) stating "The next few years will be ones of unparalleled opportunity for the RELs to demonstrate the value of their original mission, and in so doing to be a critical component of the transformation of education…" (p. 10), and Kochanek et al. (2015) proposing a new model for RELs to facilitate partnerships among researchers, teachers, and other stakeholders. Research from this study suggests various features and considerations of teacher-researcher partnerships that positively impact the implementation of new practices. This research can be used to inform policy and funding decisions to support integrated teacher and researcher projects in the future.

More and more attention is being given to teacher-researcher partnerships (Coburn & Stein, 2010; Kochanek, Scholz, & Garcia, 2015; Penuel, Allen, Coburn, & Farrell, 2015). This qualitative study using secondary analysis of data about an existing partnership contributes to an ongoing desire to understand key features of research partnerships that lead to changed instructional practices in mathematics classrooms. While nearly six years old, Coburn and Stein's (2010) book discusses researcher and teacher interactions, processes, dynamics, and design; in fact, it has served as a starting guide for many partnerships today. This study confirms similar findings of the importance of collaboration, teacher beliefs and attitudes, curriculum fit, ownership, professional learning, and closing the research-practice gap to implementation success, but adds additional important features of the partnership, specifically from the teacher's perspective, including the evolution of the partnership, the ease of implementation, the adaptability of materials, and the teacher-to-teacher collaboration. This study also draws a direct connection between the partnership and the implementation of new practices by teachers in classrooms. Overall, this study suggests a link does exist between teacher-researcher partnerships and observable practices. Besides providing implications for the design of future partnerships, in which all of the observed features should be considered, this study also suggests that the needs of student achievement in mathematics are too great for researchers to ignore the practical applications of their work. I suggest that researchers must go beyond designing studies to add to the store of knowledge about mathematics teaching and learning; they must consider how their work can benefit teachers and students immediately through engaging with a teacher-researcher partnership. Teachers who seek out opportunities to change their classroom practices should consider participating in a research-partnership. Though time constraints often scare teachers away from new commitments, this study showed benefits to teachers' professional learning and instructional practices. Additionally, this study has implications for administrators, policy makers, and funding agencies, as it calls for all groups to value the outcomes of the teacher-researcher partnership and to support this work in each of their respective ways.

Future Directions

Teacher-researcher partnerships are an emerging topic for research itself. Therefore, there are many future directions this work can take as an understanding of the benefits of teacher-researcher partnerships grows as does an understanding of the features that lead to success. First, with this existing data set, an analysis of the differences between the control classrooms and treatment classrooms could help differentiate the affects of the materials and partnership within a single teacher. As new but similar studies are considered, the direct link between the partnership and observable practices should be explored more to see if consistent data emerges. More detailed analyses could also examine the quality of the instructional practices. Because research-partnerships have not had much analysis at this level of impact, additional studies could confirm, modify, or expand upon assertions made in this study.

Second, the limitations of this study serve as a jumping point for future research. This study was a qualitative design based on analysis of secondary data. By incorporating similar research questions into a primary research design, the questions could be addressed more rigorously, through both qualitative and quantitative methods. As new methods of measuring teacher practices continue to be developed, additional measures could be added to this study, potentially reducing interpretative bias. Additional survey questions, interview questions, and observation fields could be included to dive deeper into some of the features that emerged from this analysis. A measure of MKT could also be added to test for the relationship between MKT and use of AlgebraByExample. Another limitation of this study is that of selection bias. Teachers who elected to work with the researchers may have individual characteristics that could account for differences in implementation. Short of a randomized trial, where teachers are randomly selected to participate in a partnership with researchers, additional strategies to reduce selection bias need to be investigated. Graham (2010) discussed propensity scores to address selection bias in mathematics education research with students; a similar method could be used for the teachers involved in a research partnership. The potential for teacher practices to be measured at the outset of the project could also allow for a better analysis of selection bias.

Next, recent studies of research partnerships have suggested additional frameworks under which the AlgebraByExample partnership could be examined. Penuel et al. (2015) focused their research on boundary crossings, those instances where the different backgrounds, cultures, and experiences of teachers and researchers become apparent and boundary practices, the "stabilized routines… that bring together participants from different domains for ongoing engagement" (p. 189). This study indicated positive interactions among teachers and researchers, and assuming that they did come from different backgrounds, they may have created routines and expectations as part of their group norms that mediated the negative effects of the differences to focus on the mutual benefits. These interactions and routines were not examined in this study and could serve as future work.

Finally, with the emerging research field of studying research-partnerships, many more large questions remain. Does the use of the research partnership to implement new mathematical practices lead to an increase in student achievement? Can a direct relationship be drawn between a researcher partnership and student achievement? In this study, many features of the partnership were identified; however, no attempt was made to discern the impact of each feature. We could also ask, then, which feature has the most impact on teachers' ability to implement the new mathematical practices? Another direction of research includes exploring the relationship of mathematics content and inquiry to the research-partnership benefits. If future studies continue to show benefits of teacher-researcher partnerships on the implementation of mathematics partnerships, what are the implications of this research on a larger scale? Can partnerships be scaled up to a large enough scale to impact achievement in our country? And on the opposite side of the meta-scale question, how can individual districts and researchers incorporate this work?

Current researchers who focus on teacher-researcher partnerships share the excitement for continued studies on this topic. Penuel et al. (2015) hoped "that others will imagine additional implications for [their] framework" and "that this framework provides a path beyond the list of challenges that we know research-practice partnerships face and toward a space of possible solutions to those challenges" (p. 195). Kochanek et al. (2015) similarly expressed their desire that "others might model, build upon, or revisit" (p. 1) their approach to research-practice partnerships. It is clear that there is much room for additional studies and growth in the research-partnership literature. Just as the others claimed, it is hoped that this study adds to existing knowledge and builds upon an understanding of how researchers and teachers can work together to ultimately create a better learning experience for students.

On a final note, upon reflecting metacognitively on the message of closing the research-practice gap incorporated throughout this study, how the results of this study will be communicated with school districts and researchers alike will be explored.

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APPENDIX A

EXAMPLE OF ALGEBRA BY EXAMPLE ASSIGNMENT

more
solving multi-step equations

SET 2 Solve each equation. SHOW ALL OF YOUR WORK.

Jackson **didn't** solve this problem correctly.
Here is his first step:

$3+6x=4-5x$

$3+6x=4-5x$
$9x=4-5x$

Which terms did Jackson incorrectly combine to get $9x$?

Give an example of two terms that would correctly add to $9x$.

Your Turn:

$-6x+3=4-5x$

APPENDIX B

IN CLASS STUDENT ACTIVITY DATA COLLECTION PROTOCOL

SERP-MSAN
In Class Student Activity Data Collection Protocol

AlgebraByExample

Thank you for taking the time to conduct this in-class data collection!

LOGISTICS AND CLASS DEMOGRAPHICS

Teacher: ____

Section number/class period: _______

School:____

District_____________________________

Class Time: ___________(a.m./p.m.) to ___________(a.m./p.m.)

Assignment name: ____

Assignment type: (circle one) Example or Problem

Observer Name: ____________________________

Date:______________________

Number of Students present on observation day:________

Number of Males:_______

Number of Females:______

Number of Educators present (i.e.: Student teacher, one-on-one aide). ____

Please describe: _____________________________

SERP Strategic Education Research Partnership

SERP-MSAN
In Class Student Activity Data Collection Protocol

AlgebraByExample

IN CLASS DATA COLLECTION
While the students are working on the assignment, please respond to the following:

1. Where were the assignments used? (e.g. beginning of class as a warm-up; after lesson as independent practice):
   ____

   a. How much time was spent on the assignment:_______________

2. Did students appear to be completing the assignment items in order? **(Mark one)**
   - Yes
   - No, most students completed the problems on the *left* first.
   - No, most students completed the problems on the *right* first.
   - No, most students randomly completed the assignments.

3. What was the teacher doing while students were working on the assignment **(Mark all that apply)**?
   - Circulating
   - Working with a group on something else
   - Grading
   - Answer questions only when asked
   - Talking to another teacher/school staff member
   - Other (please describe):___________

4. Did the students ask questions regarding how to work with or complete the assignments? **(Mark one)**
   - Yes
   - If yes, please describe:
     ____
     ____
     ____
   - No

5. Did the teacher(s) need to redirect student off-task behavior to encourage assignment completion? **(Mark one)**
   - Yes
     - If yes, how many times did this occur? _________
   - No

6. The students worked **(circle one):** independently, pairs, small groups.
   - The pairs/groups assigned by **(mark one):**
   - The teacher
   - Student choice
   - Based on whom the student sits next to
   - Other (please explain):____

7. Was there discussion about the assignment materials? **(Mark all that apply)**
   - Whole class discussion
   - Discussion in pairs/groups
   - No discussion

   a. If there was any form of discussion, mark **all** that apply:

	Whole Class Discussion	Discussion in Pairs/Groups	N/A
The discussion occurred before students worked on the material.			
The discussion occurred while students worked on the material.			
The discussion occurred after students worked on the material.			
The discussion was initiated by the teacher and dealt with the mathematic content.			
The discussion was initiated by the teacher and dealt with the assignment format.			
The discussion was in response to student questions about the mathematic content.			
The discussion was in response to student questions about the assignment format.			
The discussion touched on the examples.			
The discussion touched on the problems.			

8. While the class is working on study related materials, to the best of your ability please write down all of the questions asked by students and the responses provide by the teacher or a classmate below (additional space provided on the next page).

8 . (continued)

9. If you already observed this teacher using the opposite condition, were there notable differences between how the teacher introduced the assignments? Explain.

10. How did the teacher respond to "teachable moments"? (e.g. Did the teacher refuse to answer student questions, did the teachers stop and address the whole class when a common misconception arose…?

11. Please provide any additional detail you think relevant:

SERP-MSAN
In Class Student Activity Data Collection Protocol

AlgebraByExample

TEACHER INPUT

This is the least formal piece of the in class data collection – information can be collected at the time of the data collection or at a later time, either in person or over the phone. Please jot down the most important information that comes from your discussion.

- How comfortable/prepared did you feel administering and collecting the materials?
  - Not at all comfortable/prepared
  - Somewhat comfortable/prepared
  - Mostly comfortable/prepared
  - Very comfortable/prepared

- Did you feel your students were more or less motivated to complete the assignments than their typical classroom activities?
  - Less motivated
  - More motivated
  - No difference

- How much time do students typically do practice work as opposed to lecturing/taking notes?
  - Lecture/take notes:_____________
  - Practice problems/work:____________

- Are there any changes to the PD or study materials you would propose?

- Please describe any impact using the assignments may have had on your teaching practices.

APPENDIX C

MID-YEAR SURVEY QUESTIONS

(Survey was given electronically)

Timestamp
Name
District
I have received the revised Surveys 3 & 5, recycled the old ones, and placed the new ones in the expandable folders.
I am planning to administer Survey 3 and Quarterly 2 to my classes by February 15th.
I have received the missing multiplying binomials worksheet for my PROBLEM based classes.
I understand that I should be filling out an assessment checklist (on the back of the pink Admin Guides) at the time of each assessment and that I should return this checklist along with the corresponding materials.
I am aware that students should be putting their ID codes and date completed on ALL study materials.
Please reflect on the "tentative" assignment schedule you created at the start of the year. Please indicate how closely your usage aligns:
After teaching the relevant material, the assignments are typically used:
When during the class period do you typically use the assignments?
Time Limits?
Approximately how long does it typically take most students to complete assignments?

Comparing your EXAMPLE based and PROBLEM based classes, what differences do you notice in how long it takes students to complete the assignments or any other differences in how they used them?
Students typically work on the assignments:
Do students receive credit for the assignment?
While students are completing their assignments, discussion occurs with:
Do you review the assignments after they have been given?
How often are all of the items on a single assignment well-aligned with what you typically teach within 1 or 2 [consecutive] days?
Please elaborate on any details of using the assignment that you think might be helpful to us.
ID codes of students who have entered my classroom since I administered the pretest.
ID codes of students who are no longer in my classroom, but took the pretest.
Please use this space for any questions, comments and concerns you may have.
I have received a study contract indicating my expected stipend and understand that a signature is needed, as well as a W9.

APPENDIX D

END-OF-YEAR SURVEY QUESTIONS

(Survey was given electronically)

Timestamp
Name
District
Summer email or other contact information
I'm aware that all study materials including the student workbooks need to be passed from teacher to math coordinator and then sent to SERP.
Working Group meeting (all study teachers welcome, however if you did not previously attend a meeting you are not obligated to attend this one)
Are you likely to use AlgebraByExample assignments (or workbooks) in your classroom or district next year?
Please list any concerns about using AlgebraByExample in your classes/district next year:
Would you be willing to talk with other teachers or math administrators about your experiences with AlgebraByExample materials to help them decide whether and/or how to use them in their districts or classrooms?
What was your biggest challenge with the SERP study this year?
My students liked the SERP EXAMPLE based assignments more than other classroom assignments.
Compared to other assignments my students found the SERP EXAMPLE based assignments easier.

Compared to other assignments my students found the SERP PROBLEM based assignments easier.
My students generally treated the SERP study assignments like all other class work. Please check the appropriate responses for your example and problem based classes.
Did your students express frustration that they were not given a number/letter grade for the SERP assignments?
Please indicate about how often you reviewed the SERP assignments with the class as a group.
If you went over the EXAMPLE based assignments with the class as a group, please describe how you handled the discussion of the self-explanation responses.
Was there a difference in the amount of help students needed to complete the assignments in your Example vs. Problem based classrooms?
What did you like best about using the EXAMPLE based materials in your classroom this year?

APPENDIX E

EXAMPLES OF EXPLORATORY NOTING

Interview Exploratory Noting Example

Interviewer: Have you seen different curriculum or different interventions or different strategies come through, and if so, what makes the SERP project different?

Interview Transcription	Exploratory Notes
Brooke: Well, we've been um, we've been pretty, I've always been in sort of a traditionally based classroom, and only in the past I'd say 5 or 6 years have we really turned it around to the point where much more student centered activities – and, I would say around that time is when we started getting involved with SERP and it sort of fit really well into what we were doing in the class, because it wasn't all the kids lined up in rows and the teacher up at the board lecturing, it was now working in cooperative groups, and so I have had my kids for the past 4 years doing these exercises together you know, and sitting and talking about math, because one of the strengths of doing the example based problems, is it really gets the kids talking, um, it really gets them talking to each other, and it really works at the, some of these stubborn misconceptions that they have.	Recognizing student centered activities as an intentional change Connecting SERP to instructional change Fit with SERP to existing expectations of instruction for classroom Instructional change strategies – cooperative groups SERP fits with instructional change strategies – group discussion Strength of example based work is student discourse, addressing misconceptions

Observation Exploratory Noting Example

- Audrey
  - Average time spent on each assignment: 28.3 min
  - What was teacher doing? Circulating, answer questions only when asked
  - Did students ask questions about how to work with assignment? Occurred in 33% of her observations.
  - Off task behavior? Occurred in 33% of her observations.

Survey Exploratory Noting Example

- Brooke
  - Researchers requested “ID codes of students who have entered my classroom since I administered the pretest.” Brooke: “remind me later.”
  - Question: After teaching the relevant material, the assignments are typically used… Brooke: “As a refresher at least two days later”
  - Brooke typically uses the assignments at the beginning of class, but students who do not have enough time to complete are given more time later…

APPENDIX F

EXAMPLES OF COMMON THEMES PER PARTICIPANT

Interview Common Theme Example

From Brooke:

- Implementation of change – some resistant, some willing – difference is willingness to try new things/learn new things/values multiple ways to do something - "current" is important to students
- Instructional Change is an evolving process – teachers themselves change
- Many factors effect change
- Logistics were toughest part of implementation
- Evolution within the partnership (occurred together)
- Ownership of partnership through "we"
- Ease for teachers is important
- Easily accessible resources

Observation Common Theme Example

From Audrey:

- Thought it was nice having access to additional problems students can work on.
- Thought it was nice having the "ready made" examples. It made finding an example that addresses the kinds of misunderstandings students make so easy to use that she will use them more often as ways to help correct the mistakes
- Thought the assignments were good tools to use to increase student discussions on the mathematics.

Survey Common Theme Example

From Kate:

- Flexibility
    - After teaching the relevant material, the assignments are typically used… I usually use them as warm ups the next day, but have given them the same day as well as refreshers. Depends on the length of the assignment and timing on the lesson.
    - When during the class period do you typically use the assignments?... At teh beginning for warm ups/refreshers, or at the end when just taught the lesson.

APPENDIX G

EXAMPLES OF CONNECTIONS AMONG THEMES

Interview Connections Among Themes Example

From Brooke:

- Teachers add to work of researchers
    - New idea of worked examples as experiencing the math
- Evolution of change process
    - Instructional Change is an evolving process – teachers themselves change
- Evolution within the partnership (occurred together)
- Ownership
    - Ownership of partnership through "we"
    - Adaptation of research materials to practical application (and autonomy/authority to do so)
- Instructional change
    - AbE materials support instructional change
    - AbE works in parallel to existing expectations of instruction in classroom
    - Many factors effect change
    - Use of AbE without study indicates more authentic implementation
    - Adaptation of research materials to practical application (and autonomy/authority to do so)

Observation Connections Among Themes Example

From Audrey:

- Ease of Use
- Focus on Misunderstandings
- Will Use More Often
- Increased student discussion

Survey Connections Among Themes Example

Differences between working group and new-to-working group teachers:

- Support of mathematical practices/student centered classroom
    - Question: Students working on assignments…
        - Working Group: all said with a partner or group
        - New: only one said partner or group, the others were individually
    - Question: Discussion occurs with…
        - Working group more likely to say groups
        - New more likely to be with teacher or whole class

APPENDIX H

EXAMPLES OF RECURRENT THEMES

Interview Recurrent Themes Example

Theme: Evolution of SERP

- Brooke - Evolution within the partnership (occurred together)
- Isabel - SERP Changes
    - SERP had better second iteration – matches the growth narrative
- Will - Acknowledgement and appreciation of evolution of SERP model
    - Implementation challenges early on because of design, logistics

Observation Recurrent Themes Example

Theme: Encouraging Math Practices

- Teachers in all groups were similarly dispersed in their self-reported lecture to practice problems time ratios!!!!
- When working in groups, all students discussed examples at approximately the same rates in each of the groups of teachers
- Teacher actions during assignment time
    - working group was almost purely circulating and answering questions only when asked
    - the brand new group still did a lot of circulating but also completed a lot of non-instructional tasks (perhaps did not view the assignments with the same value)
    - the non working group had 2 teachers circulating but also directing the questions, and 2 teachers completely led the whole class in the example based lessons
- Big difference in students work in groups: (independent/groups)
    - Working group (50%/90%)
    - Brand new (75%/50%)
    - Non working group (53%/53%)

Survey Recurrent Themes Example

Theme: Fit

- How often are all of the items on a single assignment well-aligned with what you typically teach within 1 or 2 consecutive days?
    - Most of the time – 4 out of 8
    - Sometimes – 3 out of 8
    - All of the time – 1 out of 8

- Audrey - The questions get at some of the CCSS processes that are expected in math classrooms more than the Problem based questions do. The students must persevere through the questions, explain their reasoning, ...