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Rural Teachers' Perceptions of Collaboration and Professional Growth in Mathematics

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RURAL TEACHERS’ PERCEPTIONS OF COLLABORATION AND PROFESSIONAL GROWTH IN MATHEMATICS

By

Katherine M. Burns

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2019
RURAL TEACHERS’ PERCEPTIONS OF COLLABORATION AND PROFESSIONAL GROWTH IN MATHEMATICS

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RURAL TEACHERS’ PERCEPTIONS OF COLLABORATION AND
PROFESSIONAL GROWTH IN MATHEMATICS

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By

Katherine M. Burns
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RURAL TEACHERS’ PERCEPTIONS OF COLLABORATION AND PROFESSIONAL GROWTH IN MATHEMATICS

Abstract

By Katherine M. Burns

University of the Pacific
2019

Teachers are a focal point in rural communities, building educational and cultural connections between the families and schools they serve on a daily basis. At the same time, geography and other constraints can impact rural teachers’ access to professional development and other resources. This mixed methods exploratory study focuses on a two-year professional learning program that supported rural teachers’ \( n = 38 \) professional growth in mathematics and encouraged the development of a collaborative Community of Practice spanning 14 elementary school sites in four Northern California counties.

Research methods incorporated a secondary data analysis, as well as the collection of new data. Quantitative data collection included a survey derived from the Teacher Collaboration Assessment Rubric (TCAR; Gajda & Koliba, 2008) which yields scores regarding dialogue, decision-making, action, and evaluation. Hierarchical linear regression analyses were conducted to evaluate possible associations between participants’ perceptions about collaboration opportunities offered through the two-year professional learning program, and teachers’ self-reported and observed classroom practice and their role as mathematics leaders. In addition, independent-samples t-test analysis was conducted to address possible variation in perceptions about program collaboration among participants who did versus did not opt to complete additional hours of professional learning.
Quantitative results suggest that, as structured opportunities for decision-making and for reflective evaluation increases between program participants, lower quality mathematics instructional practice may be self-reported. It is possible that teachers initially overestimated or later changed their understanding of what constitutes quality instruction, given that initial levels were controlled in the analyses. Also, the survey results suggest that the more teachers report that collaboration occurs by reflective evaluation, the higher number of colleagues at their school site they self-report to be viewed by as a mathematics education leader, controlling for the initial level reported two years prior.

Qualitative data gathered during follow up interviews revealed that teacher participants valued the shared experience of collaborating with peers from other rural schools. Participants appreciated dialogue and problem-solving opportunities offered through engaging, rigorous math tasks and attributed this work to a building of confidence and efficacy in the classroom.

Limitations of the study, implications, and suggestions for further research are discussed.
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CHAPTER 1: INTRODUCTION

Rural schools serve as a focal point in rural communities, “influencing and being influenced” by the people they serve (Haleman & DeYoung, 2000, p. 4). As a central component of a community, rural teachers are tasked with educating children, building and reinforcing culture, and connecting families. Although they are in a position to influence an entire community, teachers in rural schools are often isolated from resources - professional, financial, and time - making it difficult for them to serve the students and families who rely on their expertise (Arnold, Newman, Gaddy, & Dean, 2005; Barrett, et al, 2015; Stewart & Matthews, 2015; Yarrow, Ballantyne, Hansford, Herschell, & Millwater, 1999). This research is an extension of a two-year professional learning program that supported rural teachers’ professional growth and encouraged the development of collaborative networks.

The professional learning program central to this research was designed to offer rural teachers opportunities to improve mathematics content knowledge and instructional practices through the building of collaborative networks by connecting educators from multiple rural districts and schools. Through ‘Communities of Practice’, educators “value the work of community building and make sure that participants have access to the resources necessary to learn what they need to learn in order to take actions and make decisions that fully engage their own knowledgeability” (Wenger, 1998, p. 10). Further, the notion of community building through shared life experiences plays an important role in shaping educators in rural settings (Gruenewald, 2003; Theobald & Siskar, 2014).

Background

In 2010, a set of national Common Core academic standards was developed and began to be adopted by individual states for their K-12 school sites. In California, the Common Core
State Standards for Mathematics emphasize student learning with a greater focus on depth of knowledge wherein skills are taught with conceptual understanding as the goal (California Common Core State Standards [CCCSS], 2013). Although the standards are consistent for all adopters, the actual implementation, including the needed professional learning for teachers, has varied among individual school districts (Walters et al., 2014). Lack of access to professional learning is a difficulty often faced by teachers in rural school districts (Arnold, Newman, Gaddy, & Dean, 2005; Barrett, et. al, 2015; Stewart & Matthews, 2015). And, as noted by Shoulders and Krei (2015), a lack of funding for professional development for rural teachers impacts their sense of self-efficacy in the classroom. Research supports the notion that teachers with a strong sense of efficacy have a positive impact on student efficacy, which in turn increases academic achievement (Bandura, 1997).

This research explores the extent to which teachers’ perceptions about their opportunities to collaborate with peers during the program were related to their professional growth as mathematics educators. Collaboration is considered as an essential tool in creation of successful learning communities to increase student achievement (DuFour & Eaker, 1998; Gajda & Koliba, 2008; Gajda & Koliba, 2009), and is especially important to support teachers in rural settings (White & Reid, 2008).

**Description of Problem**

Schools and districts nationwide have been struggling to implement the Common Core State Standards for Mathematics in an equitable manner, and teachers need support in their quest to incorporate conceptual learning within their classroom environments. This is especially true in schools serving rural communities, where teachers and administrators are faced with a lack of financial and human resources, professional development, collaboration time, and other
resources to support student achievement. (Mathis, 2010; Mentzer, et al., 2014; Shoulders & Krei, 2015). Furthermore, states have been unable to ensure equitable access to professional learning and other resources for CCSSM implementation, especially in areas typically underserved (Center on Educational Policy, 2010; Mathis, 2010). Unequal access to resources can impact teacher efficacy, which in turn impacts student efficacy and motivation (Fricke Main, 2012; Liebtag, 2013; Richardson, 2010).

This research examined professional learning in rural schools, a segment rarely studied by education scholars. Often overlooked, rural schools have often been subject to a one size fits all mentality in education reform (Schafft & Youngblood-Jackson, 2010; Schulte, 2016). Prior research suggests that effective professional learning must be relevant, timely, with adequate ongoing support (Darling-Hammond, 2009; Glover et al., 2014). Also essential is the creation of opportunities for teachers to make collaborative connections between content and pedagogy and

Purpose of Study

As an expansion of initial evaluation efforts tied to the two-year program, hereon referred to as “Abacus”, this dissertation study sought to identify and better understand possible associations between program participants’ perceptions about their opportunities to collaborate with peers during the professional learning program, and their professional growth as mathematics educators.

Research Questions

This research incorporated a secondary data analysis, as well as the collection of new quantitative and qualitative data to explore the nature and magnitude of correlations between teachers’ perceptions about peer collaboration during professional learning and their growth as mathematics educators. The following questions were addressed:
1. **Self-reported instructional practice.** After controlling for teachers’ initial self-reported rating of the quality of their daily mathematics instructional practice, to what extent can variation in their self-reported rating of the quality of their daily mathematics instructional practice, reported at the end of the two-year professional learning program, be accounted for by their perceptions of the quality of program collaboration as indicated by:
   a) Structured opportunities for dialogue between program participants?
   b) The role of teamwork in decision making?
   c) Action in application of knowledge and decisions in daily classroom practice?
   d) Evaluation - reflection on teaching practice to improve instruction?

2. **Observed practice in facilitating mathematics discourse.** After controlling for initial rubric scores connected with the observation of teachers’ role in facilitating student-led mathematics discourse, to what extent can variation in rubric scores connected with the observation of teachers’ role in facilitating student-led mathematics discourse, reported at the end of the two-year professional learning program, be accounted for by teachers’ perceptions of the quality of program collaboration as indicated by:
   a) Structured opportunities for dialogue between program participants?
   b) The role of teamwork in decision making?
   c) Action in application of knowledge and decisions in daily classroom practice?
   d) Evaluation - reflection on teaching practice to improve instruction?

3. **Role as a mathematics leader.** After controlling for the initial number of colleagues who viewed the teacher as a school-site mathematics leader, to what extent can variation in number of colleagues who viewed the teacher as a school-site mathematics leader, reported at the end of the two-year professional learning program, be accounted for by their perceptions of the quality of program collaboration as indicated by:
   a) Structured opportunities for dialogue between program participants?
   b) The role of teamwork in decision making?
   c) Action in application of knowledge and decisions in daily classroom practice?
   d) Evaluation - reflection on teaching practice to improve instruction?

4. **Mathematics Instructional Added Authorization Completion.**
   a) Is there a difference in the average perceptions of quality of program collaboration, as indicated by structured opportunities for dialogue between program participants, between program participants who did and did not earn their Mathematics Instructional Added Authorization?
   b) Is there a difference in the average perceptions of quality of program collaboration, as indicated by the role of teamwork in decision making, between program participants who did and did not earn their Mathematics Instructional Added Authorization?
   c) Is there a difference in the average perceptions of quality of program collaboration, as indicated by application of knowledge and decisions in daily
classroom practice, between program participants who did and did not earn their Mathematics Instructional Added Authorization?

d) Is there a difference in the average perceptions of quality of program collaboration, as indicated by reflection on teaching practice to improve instruction, between program participants who did and did not earn their Mathematics Instructional Added Authorization?

5. **Scope of Collaboration.** What are rural teachers’ perceptions regarding the possible effects of collaboration during a two-year professional learning program on their practice as mathematics educators?
   a) In what ways, if any, do program participants collaborate about mathematics?
   b) In what ways, if any, have participants implemented classroom practices derived from collaborative discussions with colleagues from the professional learning program?

**Significance**

A review of literature related to teacher efficacy and mathematics instruction reveals a wealth of studies conducted in a variety of educational settings. By comparison, only a few studies have been published relative to the teaching of mathematics in rural school communities. And, research on rural mathematics instruction is primarily limited to high school classrooms with very little research specific to mathematics instruction in rural schools serving K-6 students.

This research is significant in that it sheds light on professional learning in rural schools, a segment rarely studied by education scholars. Also significant is the study of possible correlations between teacher perceptions about collaboration, an essential element of learning communities (DuFour & Eaker, 1998; Gajda & Koliba, 2008; Gajda & Koliba, 2009) and professional growth as mathematics instructors. Gaining additional knowledge regarding any relationships between rural teachers’ perceptions and growth may inform the future design and implementation of professional learning opportunities in other rural settings.

**Theoretical Framework**

“Communities of Practice are organizational assets because they are the social fabric of the learning organizations” (Wenger, 1998, p. 253). As a framework, Communities of Practice is
appropriate for this study given the emphasis in Abacus on the building of a collaborative network of rural teachers through shared learning experiences (Thebald & Siskar, 2014; Wenger, 1998). Through their participation in Abacus, teachers’ experiences provided opportunities for the formation of a shared culture, where, as Wenger (1998) notes, there are opportunities to form a shared culture where there are norms and participant roles.

Participants’ shared experience is a constant force at tension with the community’s knowledge-building, which Wenger (1998) describes as a tug of war between members’ experience and competency. With social learning at the center, Communities of Practice reflect environments where “collective learning results in practices…..where there is a “sustained pursuit of a shared enterprise” (Wenger, 1998, p. 45).

Through shared experience and knowledge building, the community forms its own identity and culture (Thebald & Siskar, 2014; Wenger, 1998). However, personal identities must be valued, as well, because they are also shared attributes of any community (Wenger, 1998). One’s identity reflects the characteristics and behaviors of the community, accounting for one’s role in the group. The community is part of members’ identity, but also embraces the individuals within the community (Wenger, 1998). The Abacus program central to this research created an environment allowing development of a new community of rural school teachers.

**Description of the Study**

This research incorporated mixed methods using a sequential explanatory design, where qualitative data are used to provide additional insight regarding quantitative data collected via primary and secondary sources. McMillan and Schumacher (2010) note that a sequential design provides the opportunity to enhance quantitative data sets through subject interviews, whose responses can be analyzed to identify themes to explain or better understand processes and
outcomes. This nonexperimental research was an exploration of secondary data, coupled with the collection of new information to study correlations between rural mathematics teachers’ perceptions about collaboration during the recently completed Abacus program and several variables measuring professional growth in pedagogy, planning, discourse, and mathematics leadership.

Program evaluation data previously collected provided a foundation, measuring participants’ mathematics practice and leadership at the beginning and end of Abacus. New quantitative research included a survey of teacher perceptions about their prior collaboration with program colleagues during two years of professional learning. The researcher evaluated teachers’ perceptions about past project collaboration as a possible predictor for several criterion variables associated with professional growth as mathematics educators (McMillan & Schumacher, 2010). Follow up interviews of several participants were used to gather qualitative information to gain additional insight regarding teachers’ views.
CHAPTER 2: REVIEW OF LITERATURE

In 2011, the State of California Department of Education funded the Improving Teacher Quality grant program. The building of partnerships between four-year universities, county offices of education, and local school districts was key, and programs funded by the State were required to support students in high-poverty districts with better access to learning in the Common Core content standards through the development of professional learning for teachers in underserved districts (ITQ, 2011). This dissertation study was an extension of a two-year professional learning program funded by through an ITQ grant. The professional learning program was designed to provide support for teachers in rural schools, and the dissertation study explored the extent to which participating teachers’ perceptions about their opportunities to collaborate with peers were related to their professional growth as mathematics educators.

Chapter Two begins with a summary of relevant literature to provide context regarding national call to implement the Common Core standards as well as concerns and common pitfalls related to the quick adoption of the standards. Because this research is rooted in a professional learning program addressing the needs of teachers in rural schools, this chapter also provides a summary of prior studies on challenges faced by the schools serving these unique communities, including difficulties with access to resources for in-service teacher development.

Chapter Two also addresses researchers’ recommendations on professional development program design, and finally, an analysis of theoretical frameworks related to the development of a specific professional learning program funded by the California Department of Education intended to build engaging, collaborative working relationships among teachers serving rural schools.
The Rise of Common Core Mathematics Standards

As a means to strengthen the United States’s competitive standing in a global economy and to create a learning environment that prepared students for college and career, the Common Core standards began to take shape in 2010 (Mathis, 2010). The movement was supported, in part, by academic achievement data collected for the Program for International Student Assessment (PISA). Every three years, PISA collects academic proficiency data in mathematics, as well as other core content areas, from 15 year-olds from 72 participating education systems (PISA, 2016). A review of the most recent assessment results collected in 2015 reveals that students in the United States ranked in the bottom half of all participating countries, falling behind “Canada, Estonia, Finland, Germany, Hong Kong (China), Japan, Macao (China), New Zealand, Republic of Korea, Singapore, and Slovenia” (PISA, 2016, p. 23). Of note is an ongoing pattern since the inception of PISA in 2000, where the United States is among the countries with the highest rate (30%) of students scoring in the lowest math proficiency levels (PISA, 2016).

Common Core State standards implementation in K-12 classrooms began in 2013. In mathematics, the California Common Core standards emphasize student learning with a greater depth of knowledge, and the skills are intended to be taught with conceptual understanding as the goal (CCCS, 2013). Implementation of the new standards includes the use of eight mathematics practice standards that support conceptual teaching and learning. Students, for example, are prompted to look for patterns, use models, and justify their problem-solving strategies (CCCS, 2013). K-5 students are taught arithmetic, focusing on conceptual understanding of foundational skills related to addition, subtraction, multiplication, and division.
The foundational skills prepare students for mastery of Algebra concepts after grade five (Walters, Smith, Ford, & Torres, 2014; Zimba, 2014). And, arithmetic is referred to as the “wrench that gives students leverage” to understand more advanced math concepts (Zimba, 2014, p. 4). Mupa (2015) writes that young students missing the opportunity to master their foundational math skills are the students who suffer most when taking math courses in their later years.

Teachers providing instruction in Common Core use pedagogical strategies and content knowledge to build students’ conceptual knowledge. Strategies known as the Mathematical Practices are aligned with the Common Core standards and span all grade levels, K-12 (CCCS, 2013). The practices are designed to promote students’ critical thinking and problem-solving skills.

Gristy (2012) and Grant (2014) describe the benefits of student peer to peer collaboration and discourse in their learning environments. Collaboration and discourse allow students to practice their problem-solving skills (Grant, 2014), and research indicates there is a positive connection between collaboration and student engagement, where students can support their “mates” (Gristy, 2012).

Several research studies have demonstrated the importance of student engagement in the teaching of mathematics (Klem & Connell, 2004; Shoulders & Krei, 2015; Taylor & Parsons, 2011). When students are engaged in the learning process, they are more likely to retain what is learned in the classroom. There is a positive correlation between engagement and student achievement (Taylor & Parsons, 2011). As a result of Common Core, there has been, and will continue to be, a major shift in pedagogy, because of the critical need to emphasize conceptual learning instead of memorizing algorithms (Walters et al., 2014).
Equity Issues

The Common Core standards were designed with the intention of “equity and high-quality learning for all children everywhere” (Richardson, 2010, p. 4). Since the standards were designed with the intent of national adoption, academic expectations would be the same, in general, for all students (Liebtag, 2013; Rothman, 2011). In spite of the best of intentions to ensure similar learning experiences for all, researchers began to voice concerns that the Common Core standards would be implemented with variation between states, districts, and schools (Fricke Main, 2012; Liebtag, 2013; Richardson, 2010).

Access to financial resources is another factor affecting the equitable implementation of the Common Core standards (Mathis, 2010). The Center on Educational Policy (2010) predicted problems with several issues tied to funding and the expedited adoption of Common Core standards, including program support in districts and schools, problems with access for schools serving students of poverty, and proper development of professional development for teachers.

When implementation is unequal, expectations and student access is unequal. Fricke and Main (2012) complained that the Common Core standards were enacted too quickly, and attention should be given to ensure that teachers were prepared before “we experiment with our children” (p. 76). Tasked with evaluating teacher perceptions about Common Core, Walters et al. (2014) researched teacher perceptions regarding the Common Core standards and found a consistent belief among educators that more time was required to learn strategies for teaching more challenging math content. The teachers’ beliefs were echoed by school administrators (Walters et al., 2014).

Mupa (2015) addressed perceptions regarding student collaboration and discourse, an essential component of the new standards, and found that teachers believed they were only somewhat prepared to properly implement these new practices. Additionally, teachers noted
their concerns regarding the transition from a mathematical classroom emphasizing algorithms and worksheets, to an environment focused on student discourse and learning for a deeper understanding of concepts (Walters et al., 2014). When educators from the same schools were surveyed again a year later, concerns were largely unchanged, except for a new shift connected to sifting through the many new curricular resources to identify the best tools for student learning (Walters et al., 2015).

As noted by Barrett, Cowen, Toma, and Troske (2015), the focus of researchers has “been directed toward sources of inequality, typically defined on the basis of student racial/ethnic identity and geographic locale.” To date, little has been studied with regard to achievement gaps in rural schools, where access to professional development and other resources is often very limited (Arnold, Newman, Gaddy, & Dean, 2005; Barrett, et. al, 2015; Stewart & Matthews, 2015).

The definition of a rural school setting can vary among people or organizations. A stereotypical view of rural schools evokes images of small campuses in isolated communities. The United States Census Bureau defines a rural community in terms of what it is not. Rural communities are not urban centers, defined as areas with at least 50,000 residents. And, rural communities are not urban clusters, which are defined as areas inhabited by at least 2,500 and fewer than 50,000 people (U.S. Census Bureau, 2010).

In part because rural communities are relevant worldwide and are defined differently outside of the United States, researchers have used a variety of factors to identify rural schools in the context of conducting educational research. At times, rural schools are viewed as those located a specific distance from an urban center. Rural schools have also been identified as those serving communities with small populations. Sometimes, the definition is tied to a combination
of factors, including population and proximity, as well as the maximum number of students served by a particular campus (Stapel & DeYoung, 2011; Williams, 2005). Researchers Cromartie and Bucholtz (2008) note that rural communities are often defined based on population counts, boundaries and proximity to urban areas, as well as how land is developed or used. But, the experience of local life and offer opportunities for students to build “place shaping,” (Gruenewald, 2003, p. 637), accounting for their unique needs is essential in the education field.

Teachers in rural school settings often feel isolated in their effort to improve their own content knowledge and pedagogical practice (Babione, 2010; Schafft & Youngblood-Jackson, 2010; Schulte, 2016). Hartman (2013) profiled a new math coach serving rural schools and described challenges faced by school personnel trying to build working relationships with teachers at multiple sites. With limited coaching resources, teachers have few opportunities to build successful, trusting working relationships with leaders who can support them.

Several studies, including Glover et al. (2016), Stapel and DeYoung (2011), and Stewart and Matthews (2015) address rural schools’ limited access to financial resources. When budgets are developed, teacher professional development is given a low priority, compared to other district or school expenditures. As a result, teachers in rural schools have few opportunities for professional development when compared to their peers in suburban or urban settings (Newman, Gaddy & Dean, 2005; Shoulders & Krei, 2015).

Expanding on the notion that professional development is limited in quantity, there are also concerns regarding its quality. A few studies addressing professional development have focused on opinions of teachers and administrators in rural schools. Interview data has identified common themes related to the quality of training available in these settings, where educators are
concerned that they do not have access to support for mastering new curriculum. Of additional concern is the lack of support in building collaborative work teams to discuss, practice, and reflect on pedagogical practice (Mupa, 2015; Stewart & Matthews, 2015; Walters et al., 2014).

Additional research describes struggling teachers’ lack of support as a risk factor tied to employment stability and concern that teacher turnover leaves open positions in rural schools that struggle to recruit qualified staff (Barrett, Cowen, Toma, & Troske 2015; Player, 2015)

Rural schools’ principals struggle with professional development, too. The principals, who are charged with the responsibility of serving as campus instructional leaders, find themselves in survival mode with limited access to quality training. As a result, this set of school leaders find it difficult to provide direct support in teacher development (Stewart & Matthews, 2015). In a successful school model, Fullan (2014) suggests that principals should lead learning and develop a “group” of both principal and teacher leaders to collaborate and work together, be a district and system player where the principal contributes to and benefits from networking and external partnerships, and become a “change agent” to work through resistance and enact change and constantly seek feedback. Research suggests that when groups of teachers working together are they key to school improvement (Katzenmayer, 2001; Fullan, 2010).

Babione (2010) conducted surveys regarding the attitudes of math and science teachers in rural schools, finding they overwhelmingly felt isolated in their effort to improve their content knowledge and pedagogical practice. Hartman (2013) profiled a new math coach serving rural schools and described challenges faced by school personnel trying to build working relationships with teachers at multiple sites. With limited coaching resources, teachers have few opportunities to build successful, trusting working relationships with leaders who can support them.
Although most of the research performed to date highlights rural schools’ struggle to provide quality professional development, a recently published survey comparing teacher training in rural and urban settings found few differences between educational opportunities offered to educators in either setting (Glover et al., 2016). The authors noted a few concerns regarding subjects’ completion of the survey, given its length and the timing of its completion relative to the teacher’s last professional development session. Further study was recommended.

Difficulties with access to quality staff development contribute to teacher and administrator retention, another challenge faced by rural schools. Prior researchers have acknowledged rural schools’ struggle to recruit, hire, train, and retain qualified teachers (Arnold, Newman, Gaddy & Dean, 2005; Shoulders & Krei, 2015). Additional research by Barrett, Cowen, Toma, and Troske (2015) describe struggling teachers’ lack of support through professional development, which leads to a risk that a school will terminate their employment leaving an open position, which can be difficult to fill in a rural setting. Rural schools’ principals struggle with professional development, too. The principals, who are charged with the responsibility of serving as campus instructional leaders, find themselves in survival mode with limited access to quality training. As a result, this set of school leaders find it difficult to provide direct support in teacher development (Stewart & Matthews, 2015).

A review of research reveals rural schools’ struggles with teacher preparation and support, content knowledge, and efficacy as it relates to student engagement. Shoulders and Krei (2015) discuss the challenges with rural schools’ location and a limited number of qualified teachers to fill open positions. The authors attribute part of the problem to school funding (Shoulders & Krei, 2015), leading to a lack of teacher training and thus a lack of efficacy in the classroom. The researchers also found connections between collaborative professional
development and teacher efficacy. In a study of professional development for general and special education teachers, noting a “predictive relationship” between the quantity and quality of professional development and teachers’ ability to engage students in daily lessons (Shoulders & Krei, 2016). Similarly, Mupa (2015) found a correlation between professional development and the competent teaching of mathematics.

Research supports the notion that teachers with a strong sense of efficacy have a positive impact on student efficacy, which in turn increases academic achievement (Bandura, 1997). When considering equity in education, Glover et al. (2016), address the struggles of beginning teachers in their effort to support students faced with socio-economic difficulties. The authors note that access to ongoing support through peer collaboration and professional development has a positive impact on the effectiveness of beginning teachers, and ultimately students’ learning. Teacher and administrator skill and confidence levels contribute to the overall school culture, as do influences from the surrounding community. Often, schools in rural settings are faced with challenges related to poverty, which impacts students’ access to resources outside of the classroom environment. Poverty is poverty, regardless of the setting, rural or otherwise (Williams, 2005). Considering difficulties faced at home, including challenges with access to resources, students facing poverty in any school environment face similar deficits in mathematics achievement, as measured by standardized tests (Williams, 2005). While poverty is not a problem unique to rural schools, it is an additional challenge impacting campus culture.

Poverty is aligned with the structure of rural families, as discussed by Roscigno and Crowley (2001). The authors describe the connection between limited educational resources, the availability of quality employment, and stress on a family’s budget. When homes are under economic pressure, there is a connection with turmoil that can impact the family unit, stress and
strain on parents, and their ability to support children with school (Roscigno & Crowley, 2001; Williams, 2015). With limited educational and work opportunities, schools are tasked with filling the academic and emotional gap (Barrett et al., 2015; Roscigno & Crowley, 2001). Roscigno and Crowley (2001) write, “Rural schools will resemble rural families in their degree of resources” (p. 270).

In addition to pressures faced by parents in rural communities, research indicates traditional family roles as impacting school culture. Lamb and Daniels (1993) described family units that tend to place significance on the traditional roles of boys and girls, thus impacting a student’s path in pursuing his or her education. As a result of a culture placing value on traditional roles, girls are less likely to pursue studies in math, science, or other related fields. (Lamb & Daniels, 1993). And, while the notion of college-readiness is emphasized to a lesser extent in rural communities, boys are more likely than girls to pursue educational opportunities leading to college and careers other than those stereotypically held by women (Lamb & Daniels, 1993; Roscigno & Crowley, 2001).

Research specific to rural schools is very limited, especially in the area of math and science in elementary classrooms. Arnold et al. (2005) describe an environment where “a considerable amount of literature is published each year that purports to be rural education research, yet some of it is related only peripherally to rural education” (p. 2). Barrett et al. (2015) agree that the topic of rural education “remains under-examined” (p. 1). In their findings and recommendations, researchers have consistently urged additional studies to examine any variety of issues related to educational experiences and challenges related to rural schools (Arnold et al., 2005; Barrett et al., 2015; Hartman, 2013; Howley, Wood, & Hough, 2011; Stapel & DeYoung, 2011).
Components of Effective Professional Development

Research highlighted in this literature review has addressed limited professional development opportunities in rural schools. Additional research on the topic of professional development finds common themes for any educational setting. First, research supports the notion that teachers value professional development relevant to their practice (Darling-Hammond, 2009; Glover et al., 2014). Liebtag (2013) and Walters et al. (2014) outline the importance of creating opportunities for teachers to make collaborative connections between the Common Core standards and teaching practices. The opportunity to share and discuss real-world teaching strategies is an essential component of meaningful professional development.

In addition to taking steps to make professional development relevant, Glover et al. (2016) discuss the importance of devoting enough time for each learning session, and ensuring the duration of professional development is appropriate to support teachers over an appropriate time span. Research supports a connection between the number of hours and duration of professional development and the depth of teachers’ content knowledge (Darling-Hammond, 2009; Glover et al., 2016).

Darling-Hammond (2009) cites evidence supporting the notion that our educational system is lacking in its professional development time commitment. She writes:

While teachers typically need substantial professional development in a given area (close to 50 hours) to improve their skills and their students’ learning, most professional development opportunities in the U.S. are much shorter. On the 2003-04 national Schools and Staffing Survey (SASS), a majority of teachers (57 percent) said they had received no more than 16 hours (two days or less) of professional development during the previous 12 months on the content of the subject(s) they taught. This was the most frequent area in which teachers identified having had professional development opportunities. Fewer than one-quarter of teachers (23 percent) reported that they had received at least 33 hours (more than 4 days) of professional development on the content of the subject(s) they taught (p. 5).
In between professional development sessions, teachers are supported through peer collaboration and positive working relationships with academic coaches (Barrett et al., 2015; Hartman, 2013). In her analysis of the coach and teacher relationship, Hartman (2013) describes many obstacles faced by school personnel as positive working relationships are formed. The relationships require the building of trust between all parties, and require time, patience, and persistence.

Professional learning communities have been embraced as a strategy for raising student achievement, and effective collaboration is an essential component (DuFour & Eaker, 1998; Gajda & Koliba, 2008; Gajda & Koliba, 2009). At its core, collaboration has four attributes; dialogue, decision making, action, and evaluation (Gajda & Koliba, 2008; Lehman, Kim, & Harris, 2014; Zito, 2011). Collaboration attributes are more fully defined and can be reliably measured using the Teacher Collaboration Assessment Survey, a rubric-based tool for evaluating teacher perceptions (Gajda & Koliba, 2008; Zito, 2011).

As defined by Gadja and Koliba (2008), collaborative dialogue in high functioning groups places an emphasis on conversations that are “pre-planned, prioritized, and documented,” with team members meeting face to face (p. 144). Decision making, the second of four dimensions of professional collaboration, is high functioning when groups place an emphasis on shared efforts and team-based choices that are connected to improvement of teaching and learning (Gadja & Koliba, 2008). Groups that are high functioning in the action regularly apply team decisions to daily classroom practice (Gadja & Koliba, 2008). And evaluation, the fourth dimension of collaboration, is high functioning when groups regularly collect data and reflect on their daily practice to improve teaching and learning.
While teacher collaboration has been connected with positive teaching and learning outcomes (Gajda & Koliba, 2008; Lehman, Kim, & Harris, 2014; Zito, 2011). Lehman, Kim, and Harris (2014) noted the importance of pairing collaborative efforts with professional learning to support teachers’ ongoing development. Additional research has supported the idea that teacher collaboration is an essential component to professional development programs (Darling-Hammond, 2009; Glover et al., 2016; Mainzer & Mainzer, 2008; Stewart & Matthews, 2015; Walters et al., 2014).

Collaboration, while difficult to schedule, is part of our educational future. Mainzer and Mainzer (2008) characterize teacher isolation in their own classrooms as a thing of the past, and Darling-Hammond (2009) notes that our system prioritizes teachers’ need to be in the classroom with students and de-emphasizes the benefit of collaboration among colleagues to design and evaluate curriculum. Darling-Hammond (2009) cites research showing that “American teachers spend about 80 percent of their total working time engaged in classroom instruction, as compared to about 60 percent for these other nations’ teachers” (p. 6). Working together to share ideas is critical for all teachers in our current educational environment and is often valued more than observational feedback from administrators (Stewart & Matthews, 2015).

In addition, teachers need ongoing support in their purposeful selection of qualitative and quantitative data to better understand student needs (Van Gasse, Vanlommel, Vanjoof, & Van Petegem, 2016). Meaningful data analysis is an essential component of teacher reflection, impacting daily practice (Van Gasse et al., 2016).

**Mathematics Teacher Leadership**

Teachers participating in leadership programs can impact the culture of efficacy at their sites. A common characteristic of teacher leaders is the commitment to ongoing development to build content knowledge (Mentzer et al., 2014; Mupa, 2015). Research reveals connections
between the teacher’s expertise in content and the openness of other staff to consult with them for recommendations to improve the quality of teaching (Mentzer, et al., 2014).

Several studies have documented the impact of increased content knowledge and teacher confidence. Confident teacher leaders strengthen their pedagogical practice through a deeper understanding on content and ongoing professional development to learn and practice a variety of strategies for reaching all learners (Mentzer, et al., 2014; Shoulders & Krei, 2015; Riveros, 2013).

Often, there is initial administrative support for teacher leadership programs. However, the support can wane when principals are strapped with other responsibilities. Riveros (2013) profiled a group of teacher leaders who persevered in their professional development despite limited support from school and district administrators. Further research would provide additional insight regarding the implications of self-directed teacher leadership efforts (Riveros, 2013).

**Communities of Practice**

Under the right conditions, successful teaching teams can be formed and sustained. Fitzgerald and Theilheimer (2013) define successful teams as those where teachers have a shared commitment to communication and a sense of trust in the way they use pedagogical practices in the classroom. Further, they share a common vision regarding their own professional growth (Chong & Kong, 2012; Fitzgerald & Theilheimer, 2013). The notion of resilience plays a role in the making of successful teams as well, with teachers supporting one another “as a buffer, protecting their beliefs from external challenges” (Greenfield, 2015, p. 54).

Wenger (1998) explains that Communities of Practice are rooted in social theory, “at the intersection of philosophy, the social sciences, and the humanities” (p. 12). With social learning
at the center, Wenger (1998) describes two pairs of social theory categories in constant tension with one another. As illustrated in Figure 1 below, theories of social structure at odds with theories of situated experience. Social structure theories consider rules, norms, and institutions, whereas situated experience theories address personal interaction and ordinary experiences.

![Figure 1. Social Theories of Learning. Wenger (1998, p. 12).](image)

Figure 1 also illustrates the way theories of practice are at odds with theories of identity. Social practice theories address “social systems of shared resources,” and theories of identity are concerned with the individual person (p. 13). Wenger (1998) indicates the opposing groups of theories “set the main backdrop” for the communities of practice framework (p. 13).

In terms of practice, “collective learning results in practices…..where there is a “sustained pursuit of a shared enterprise” (Wenger, 1998, p. 45). Identity considers the characteristics and behaviors of the community but does not ignore the individual. Although, over time, the individual’s identity is embedded within the community (Wenger, 1998).
Communities of practice have a central focus on knowledge and learning, as noted by Wenger (1998), who writes about the need for a constant tug of war between members’ experience and competency. Predefined common goals are a “central factor defining the enterprise” for teacher collaboration (Wenger, 1998, p. 45). The learning community, however, extends beyond mere progress toward a defined goal with teachers sharing professional as well as social experiences, creating their own language and norms, and building an identity as participants in a common group (Wenger, 1998). Shared experiences in discovery, collective knowledge building, and the mere act of participating in a collaborative professional development group builds a sense of community (Wenger, 1998).

Wenger (1998) explains that communities of practice include a focus on identity, but one’s identity is not entirely defined by the community. Individuality is essential, but there is also “shaping by belonging to a community, but with a unique identity” (Wenger, 1998, p. 146). In addition, identity is dependent on “engaging in practice, but with a unique experience” (Wenger, 1998, p. 146).

Communities of practice theory has been widely used as a framework in educational and other scholarly research. Bradbury and Middlemiss (2015) used the framework to study Green Action, an environmental action organization. Though their shared pursuits and community building, the group sustained its recycling goals in a university community. Green Action designed its structure to facilitate and honor shared leadership among group members, and the organization has continued to grow its environmental efforts beyond its initial recycling effort.

Kinloch, Nemeth, and Patterson (2015) used communities of practice as a theoretical framework during the study of an educational service learning project involving teachers’ union members and a research university. Participants developed partnerships with local organizations
to develop and implement service learning opportunities for K-12 students in an urban school district. A central goal for the program was to expand on traditional teaching methods, providing students with experiential learning through their community participation. In their findings, the authors described the way students’ identities were linked to their volunteer work, as the result of their involvement with the community of practice (Kinloch et al., 2015).

Brown and Duguid (1991) applied Wenger and Leve’s notion of legitimate peripheral participation, a component of early community of practice theory, to the workplace culture at Xerox. The authors studied the organization’s goal of improving innovation and work practice, and made recommendations for Xerox to move beyond the company’s formal rules and procedures to better understand and value employees’ seemingly informal discussions and efforts, a necessary component to collective learning and process improvement.

**Conclusion**

This review of literature provides background knowledge on the challenges faced by educators while implementing Common Core Mathematics Standards, especially in rural community schools where time, funding, and human resources are often lacking. Relevant, high-quality professional learning may provide teachers with the tools they need to implement the new standards, improve instructional practice, and raise student achievement.

Taking measures to ensure that professional learning is relevant, timely, and offers ongoing support is one step to ensure a quality program for teachers. Research suggests that programs might be more effective when teachers have opportunities for sustained collaboration on the topics covered by their professional learning programs (Gajda & Koliba, 2008; Lehman, Kim, & Harris, 2014; Zito, 2011).
Little research exists to address teacher collaboration during professional learning and sustained practice in the classroom, especially in K-8 mathematics. And, rural populations have not been studied in this regard. This dissertation research intends to explore correlations between teacher perceptions about the quality of collaboration in a rural schools’ professional learning program, and professional growth in mathematics instruction.
CHAPTER 3: METHODOLOGY

This research was connected to a two-year professional learning program designed to serve K-8 teachers from rural schools in several Northern California counties. During the two-year program, participating teachers attended meetings and workshops to build deeper understanding of mathematics content, learning trajectories, and pedagogy aligned with the California Common Core Standards.

Professional learning is most effective when it is relevant and ongoing, with opportunities to experience subject matter at a greater depth (Darling-Hammond, Chung Wei, Andree, Richardson, & Orphanos, 2009; Riveros, 2013; Shoulders & Krei, 2015). Teachers enrolled in the two-year program participated in small site-based meetings and project-wide whole-group workshops at least six times during each school year, plus two intensive two-week mathematics institutes during summer breaks. A central focus of the program was to build collaborative, supportive working relationships among teachers from different sites, districts, and counties.

Purpose of Study

This research built upon evaluative components from the two-year professional learning program. The purpose of this study was to explore the extent to which teachers’ perceptions about their opportunities to collaborate with peers during the professional learning program were related to their professional growth as mathematics educators as well as to better understand the nature of that association.

Research Questions

This research incorporated a secondary data analysis, as well as the collection of new quantitative and qualitative data to explore the nature and magnitude of correlations between
teachers’ perceptions about peer collaboration during professional learning and their growth as mathematics educators. The following questions were addressed:

1. **Self-reported instructional practice.** After controlling for teachers’ initial self-reported rating of the quality of their daily mathematics instructional practice, to what extent can variation in their self-reported rating of the quality of their daily mathematics instructional practice, reported at the end of the two-year professional learning program, be accounted for by their perceptions of the quality of program collaboration as indicated by:
   a) Structured opportunities for dialogue between program participants?
   b) The role of teamwork in decision making?
   c) Action in application of knowledge and decisions in daily classroom practice?
   d) Evaluation - reflection on teaching practice to improve instruction?

2. **Observed practice in facilitating mathematics discourse.** After controlling for initial rubric scores connected with the observation of teachers’ role in facilitating student-led mathematics discourse, to what extent can variation in rubric scores connected with the observation of teachers’ role in facilitating student-led mathematics discourse, reported at the end of the two-year professional learning program, be accounted for by teachers’ perceptions of the quality of program collaboration as indicated by:
   a) Structured opportunities for dialogue between program participants?
   b) The role of teamwork in decision making?
   c) Action in application of knowledge and decisions in daily classroom practice?
   d) Evaluation - reflection on teaching practice to improve instruction?

3. **Role as a mathematics leader.** After controlling for the initial number of colleagues who viewed the teacher as a school-site mathematics leader, to what extent can variation in number of colleagues who viewed the teacher as a school-site mathematics leader, reported at the end of the two-year professional learning program, be accounted for by their perceptions of the quality of program collaboration as indicated by:
   a) Structured opportunities for dialogue between program participants?
   b) The role of teamwork in decision making?
   c) Action in application of knowledge and decisions in daily classroom practice?
   d) Evaluation - reflection on teaching practice to improve instruction?

4. **Mathematics Instructional Added Authorization Completion.**
   a) Is there a difference in the average perceptions of quality of program collaboration, as indicated by structured opportunities for dialogue between program participants, between program participants who did and did not earn their Mathematics Instructional Added Authorization?
   b) Is there a difference in the average perceptions of quality of program collaboration, as indicated by the role of teamwork in decision making, between
program participants who did and did not earn their Mathematics Instructional Added Authorization?
c) Is there a difference in the average perceptions of quality of program collaboration, as indicated by application of knowledge and decisions in daily classroom practice, between program participants who did and did not earn their Mathematics Instructional Added Authorization?
d) Is there a difference in the average perceptions of quality of program collaboration, as indicated by reflection on teaching practice to improve instruction, between program participants who did and did not earn their Mathematics Instructional Added Authorization?

5. Scope of Collaboration. What are rural teachers’ perceptions regarding the possible effects of collaboration during a two-year professional learning program on their practice as mathematics educators?
   a) In what ways, if any, do program participants collaborate about mathematics?
   b) In what ways, if any, have participants implemented classroom practices derived from collaborative discussions with colleagues from the professional learning program?

Significance

This research sought to shed light on professional learning in rural schools, a segment rarely studied by education scholars. Of the few studies available for review, findings indicate that rural schools struggle with funding and other resources, preventing access to professional learning (Mathis, 2010; Mentzer, et al., 2014; Shoulders & Krei, 2015). Gaining additional knowledge regarding any relationships between rural teachers’ backgrounds, perceptions, and experience in this specially designed professional learning program could inform the future design and implementation of professional learning opportunities in other rural settings.

Participants

Participants selected for this research submitted applications and met eligibility requirements for Abacus. The program was designed to serve a total of 35 teachers from rural schools in Northern California, with three extra participants invited to participate to fill gaps in the event of attrition. In order to qualify for the professional learning program and the study, rural community teachers were required to provide mathematics instruction for all or part of the
school day, in any grade from kindergarten to eighth. Participants from traditional public schools, publicly funded charter schools, and private schools were eligible for the program.

Following a three-month recruitment and selection effort targeting rural schools in a five-county area, the resulting sample of 38 participants were selected from an accessible population of teachers whose sites were located within a 75-mile radius of the researcher. The sample was comprised of a group of kindergarten through eighth grade teachers representing four counties and 14 different rural school sites. Table 1, below, provides background details for the participants in the sample.
Table 1
Participant Backgrounds

<table>
<thead>
<tr>
<th>Variable</th>
<th>Subgroups</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of Experience</td>
<td>1-4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5-9</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>10-14</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>15-19</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>20+</td>
<td>5</td>
</tr>
<tr>
<td>Assignment Type</td>
<td>All Subjects</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Math Only</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Special Education</td>
<td>1</td>
</tr>
<tr>
<td>Grade(s) Taught</td>
<td>Kindergarten</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>First</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Second</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Third</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Kinder-Third Combo</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Fourth</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Fifth</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Fourth-Fifth Combo</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sixth</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fourth-Eighth Combo</td>
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</tr>
<tr>
<td></td>
<td>Sixth-Eighth Combo</td>
<td>6</td>
</tr>
<tr>
<td>School Type</td>
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</tr>
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<td></td>
<td>Public Charter</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Private</td>
<td>3</td>
</tr>
</tbody>
</table>

Note. N = 38.

IRB approval was obtained for the original evaluation study. Abacus participants provided informed consent for data collection during the initial project and were assigned unique, confidential identification numbers (known only to the project evaluator, who chaired this dissertation study) to provide on all survey materials in lieu of names or other identifiers. Each participant received a $2000.00 yearly stipend, thus a total of $4000.00, in exchange for attending the 180 hours of workshops and meetings required for the program, which was completed in December, 2017.
Through their participation in required workshops and meetings, teachers enrolled in the Abacus program accessed professional learning to build understanding and strengthen practice in facilitating mathematical discourse among students. In addition, program workshops provided opportunities for participants to build content knowledge and pedagogical practice aligned with the California Common Core State Standards in Mathematics from kindergarten through Algebra I/Integrated Math I. Finally, teachers enrolled in Abacus were given support in the analysis of curricular resources, the building of leadership skills, and the development of inquiry-focused project-based math units.

Abacus participants seeking additional professional growth were offered the option to complete an additional 45 hours of coursework to earn a Mathematics Instructional Added Authorization (MIAA) certificate. Teachers choosing the MIAA option attended courses designed to improve assessment practice and build capacity for addressing equity in mathematics instruction. MIAA completers designed and facilitated action research in their classrooms, addressing mathematics practices relevant to their schools.

Following IRB approval, additional data used in this dissertation study was collected through a survey and participant interviews. Informed consent was obtained separately for these two forms of data collection (see Appendix A). Survey respondents were prompted to use the confidential identification numbers previously assigned, and their data is reported anonymously. Interview data has been synthesized and reported anonymously as well. In exchange for survey completion, respondents were eligible to win one of five $35.00 Amazon gift cards, awarded in a random drawing. Seven participants were interviewed following the survey, each eligible for one of three $35.00 gift cards, also awarded in a random drawing.
Design and Methodology

Mixed Methods

This research incorporated mixed methods using a sequential explanatory design, where qualitative data were used to provide additional insight regarding quantitative data collected via primary and secondary sources. McMillan and Schumacher (2010) note that a sequential design provides the opportunity to enhance quantitative data sets through subject interviews, whose responses can be analyzed to identify themes to explain or better understand processes and outcomes.

Correlational Study

This nonexperimental research involved an exploration of secondary data, coupled with the collection of new information to study correlations between rural mathematics teachers’ perceptions about collaboration during the recently completed Abacus program and several variables measuring professional growth in practice, discourse, mathematics leadership, and extension of their professional licensure (Mathematics Instructional Added Authorization [MIAA]). McMillan and Schumacher (2010) describe correlational design as seeking to understand connections between “two or more phenomena” (p. 22). A correlational design was best suited for this research, since all teachers participated together, completing the two-year Abacus professional learning program. Participants were not randomly selected or randomized in terms of their assignment. Instead, they were participants in a shared collaborative project intended to strengthen their mathematics instructional practice and build sustaining professional collaboration networks to support teachers in schools serving rural communities. Furthermore, the quantitative portion of the dissertation study was considered correlational because it is difficult to determine whether the quality of collaboration should be considered as an outcome of
Abacus or an impact on the professional learning associated with Abacus. Across the two years, it was most likely both an outcome and an input.

Program evaluation data previously collected provided a foundation, measuring participants’ mathematics practice, discourse, leadership, and extended study (MIAA) at the beginning and end of Abacus. New quantitative research included a survey of teacher perceptions about their prior collaboration with program colleagues during two years of professional learning. In other words, teachers were asked about their collaboration during the timeframe that was roughly between the pretest and posttest data that was collected for the prior evaluation study. The researcher evaluated teachers’ perceptions about past project collaboration as a possible predictor for several criterion variables associated with professional growth as mathematics educators (McMillan & Schumacher, 2010). Follow up interviews of seven Abacus participants were conducted for the purpose of gathering qualitative information to gain additional insight regarding teachers’ views.

**Instrumentation**

Table 2, below, outlines the variables and data collection instruments connected with this research.
<table>
<thead>
<tr>
<th>Variable</th>
<th>RQ #</th>
<th>Conceptual Definition</th>
<th>Operational Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration-Discussion</td>
<td>1a</td>
<td>As defined by Gadja and Koliba (2008), dialogue is one of four dimensions of professional collaboration. High functioning collaborative groups place an emphasis on dialogue that is “pre-planned, prioritized, and documented,” with team members meeting face to face (p. 144).</td>
<td>Respondents rank nine (9) survey items using a five-point Likert scale to express their level of agreement or disagreement with each statement. Level one (strongly disagree) is defined as low functioning, and level five (strongly agree) is defined as high functioning. Responses to the nine survey items are combined for a composite score.</td>
</tr>
<tr>
<td></td>
<td>2a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1b</td>
<td>As defined by Gadja and Koliba (2008), decision making is the second of four dimensions of professional collaboration. High functioning collaborative groups place an emphasis on decision making made by the team, with an emphasis on choices that are connected to improvement of teaching and learning.</td>
<td>Respondents rank six (6) survey items using a five-point Likert scale to express their level of agreement or disagreement with each statement. Level one (strongly disagree) is defined as low functioning, and level five (strongly agree) is defined as high functioning. Responses to the nine survey items are combined for a composite score.</td>
</tr>
<tr>
<td></td>
<td>2b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1c</td>
<td>As defined by Gadja and Koliba (2008), action is the third of four dimensions of professional collaboration. High functioning collaborative groups regularly apply team decisions to their daily classroom practice.</td>
<td>Respondents rank four (4) survey items using a five-point Likert scale to express their level of agreement or disagreement with each statement. Level one (strongly disagree) is defined as low functioning, and level five (strongly agree) is defined as high functioning. Responses to the nine survey items are combined for a composite score.</td>
</tr>
</tbody>
</table>
(Table 2 Continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>RQ #</th>
<th>Conceptual Definition</th>
<th>Operational Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration-Evaluation</td>
<td>1d</td>
<td>As defined by Gadja and Koliba (2008), evaluation is the fourth dimension of professional collaboration. High functioning collaborative groups regularly collect data and reflect on their teaching practice to improve teaching and learning.</td>
<td>Respondents rank four (4) survey items using a five-point Likert scale to express their level of agreement or disagreement with each statement. Level one (strongly disagree) is defined as low functioning, and level five (strongly agree) is defined as high functioning. Responses to the nine survey items are combined for a composite score.</td>
</tr>
<tr>
<td></td>
<td>2d</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3d</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4d</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Predictor</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Self-Perception</td>
<td>1a</td>
<td>Using the Silicon Valley Math Initiative (SVMI) Mathematics Teaching Rubric, participants self-reported their perceptions of their own teaching practice. In its rubric, SVMI considers the assignment of worthwhile math tasks, the use of assessment, mathematical discourse, and a positive learning environment as essential components of the classroom.</td>
<td>Using six (6) rubric categories having a one-four-point scale, teachers rated their math practice in the following areas:</td>
</tr>
<tr>
<td>of Current Practice</td>
<td>1b</td>
<td></td>
<td>- Quality of tasks</td>
</tr>
<tr>
<td></td>
<td>1c</td>
<td></td>
<td>- Learning environment</td>
</tr>
<tr>
<td></td>
<td>1d</td>
<td></td>
<td>- Facilitating discourse</td>
</tr>
<tr>
<td><strong>Criterion</strong></td>
<td></td>
<td></td>
<td>- Supporting student discourse</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Enhancing discourse</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Use of assessments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Teachers’ self-reported scores for the six subscales were combined as a composite.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Continuous Variable</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>(6 - 24 points possible)</em></td>
</tr>
</tbody>
</table>
(Table 2 Continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>RQ #</th>
<th>Conceptual Definition</th>
<th>Operational Definition</th>
</tr>
</thead>
</table>
| Observed Classroom Practice, Role in Leading  | 2a   | The Math Talk Learning Community Rubric (NCTM, 2004) addresses four components of mathematics practice: questioning, explaining mathematical thinking, source of mathematical ideas, and responsibility for learning. Each component is subdivided so that each is assessed based on teacher practice and student action. Rubric scores ranging from zero (teacher led, traditional classroom) to three (teacher as co-teacher and co-learner) were used to evaluate teachers’ and students’ roles in mathematical discourse. | Eight (8) rubric categories describe four components of teacher-led and four components of student-led discourse. These include:  
• Teacher as questioner  
• Teacher as explainer of mathematics  
• Teacher as source of mathematics ideas  
• Teacher’s responsibility for learning  
• Students as questioners  
• Students as explainers of mathematics  
• Students as source of mathematics ideas  
• Students’ responsibility for learning  
Individual scores for the eight categories listed above, each ranging from zero to three, were combined as a composite.  
*Continuous Variable (0 - 24 points possible)* |
| Discourse                                     | 2b   |                                                                                                                                                                                                                      |                                                                                                                                                                                                                      |
|                                               | 2c   |                                                                                                                                                                                                                      |                                                                                                                                                                                                                      |
|                                               | 2d   |                                                                                                                                                                                                                      |                                                                                                                                                                                                                      |
| **Criterion**                                 | 3a   | A survey developed specifically for the professional learning program includes a question addressing mathematics leadership. Respondents indicate how many colleagues view them as a mathematics education leader. | Respondents use initials to indicate colleagues supported, but the actual number of teachers they support is the focus.  
*Continuous Variable (values ranging from 0-10)* |
| Resources and Collaboration Survey           | 3b   |                                                                                                                                                                                                                      |                                                                                                                                                                                                                      |
|                                               | 3c   |                                                                                                                                                                                                                      |                                                                                                                                                                                                                      |
|                                               | 3d   |                                                                                                                                                                                                                      |                                                                                                                                                                                                                      |
(Table 2 Continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>RQ #</th>
<th>Conceptual Definition</th>
<th>Operational Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIAA Completion</td>
<td>4a</td>
<td>During Abacus, participants had the option of enrolling in an additional five units of coursework to earn a Mathematics Instructional Added Authorization (MIAA), a California credential authorization allowing educators to expand the scope of their mathematics instruction.</td>
<td>MIAA completion is dichotomous, with possible responses limited to yes or no.</td>
</tr>
<tr>
<td></td>
<td>4b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4c</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criterion</td>
<td></td>
<td></td>
<td>Categorical</td>
</tr>
</tbody>
</table>

Predictor variables: This research involved the use of a modified survey instrument, incorporating language from the Teacher Collaboration Assessment Rubric (TCAR) and Teacher Collaboration Assessment Survey (TCAS) (Gajda & Koliba, 2008; Zito, 2011). The TCAR is rooted in the Communities of Practice framework (Gajda & Koliba, 2008; Gajda & Koliba, 2009; Wenger, 1998) and aligns with schools’ work to build professional learning communities to increase academic achievement where collaboration is an essential tool for success (DuFour & Eaker, 1998; Gajda & Koliba, 2008; Gajda & Koliba, 2009). The TCAR addresses four key attributes of teacher collaboration: dialogue, decision making, action, and evaluation. Rubric scores at the lowest level, a one, are characteristic of groups lacking collaborative culture. The highest score, a six, characterizes the actions of highly collaborative groups.

The TCAS incorporates language from the TCAR and has been widely used by schools and districts to measure perceptions about collaboration in professional learning communities (Gajda & Koliba, 2008; Woodland, Lee, and Randall, 2013; Zito, 2011). The survey includes 39
statements that are ranked using a six-point Likert scale, with items aligned to the four components of teacher collaboration set forth in the original rubric. Woodland, Lee and Randall (2013) completed a validation study of the TCAS with results supporting several aspects of instrument validity: content-based evidence, response process evidence, internal structure, relation to other variables, and convergent and discriminant evidence.

Woodland, Lee, and Randall (2013) revealed findings as follows: In terms of content-based evidence, the TCAS was found to accurately measure the four components of collaboration set forth in the TCAR. Researchers evaluated a series of pre-and post-survey responses using the instrument to confirm that the instrument’s purpose was understood by those using the survey. Internal structure validity testing revealed that “items in the scale are working well together to define their construct” (Woodland, Lee, & Randall, 2013, p. 451). In addition, internal structure validity is supported by the authors’ analysis of data addressing separation of persons, with findings to suggest the scale “reasonably separates persons along the scales” relative to low and high levels of collaboration (Woodland, Lee, & Randall, 2013, p. 452). Woodland, Lee, and Randall (2013) cited evidence from a previous study (Zito, 2011), wherein the survey instrument was used during research to investigate correlations between teacher collaboration and student achievement, and where statistically significant relationships were found. When addressing convergent and discriminant evidence, the authors reported evidence of correlation between items measuring dialogue, decision making, action, and evaluation constructs.

As previously noted, this research involved a survey instrument adapted from a modified version of the TCAS (see Appendix B). The modified survey is a shorter version of the original and included 24 statements ranked by respondents, using a five-point Likert scale to indicate the
extent of agreement or disagreement with each item. Nine of the 24 survey items addressed collaboration dialogue, six addressed collaborative decision-making, four addressed collaborative action-taking, and another four addressed collaborative evaluation. The survey also included several open-ended questions providing respondents the opportunity to share details, elaborating on their perceptions about collaboration (Lehman, Kim, & Harris, 2014; Zito, 2011).

Two prior studies addressed reliability of the modified survey instrument (Lehman, Kim, & Harris, 2014; Zito, 2011) with overall Cronbach alpha reliability coefficients of .92 and .93, respectively. Lehman, Kim, and Harris (2014) additionally addressed Cronbach reliability coefficients for questions prescribed to the four collaboration categories: dialogue = .72; decision making = .79; action = .74; evaluation = .75. With potential values between zero and one, Cronbach alpha coefficients in excess of .70 are generally accepted as reliable (McMillan & Schumacher, 2010).

**Criterion variables:** This dissertation study set forth to explore the nature and magnitude of correlations between teachers’ perceptions about collaboration during Abacus and professional growth. In addition, the researcher sought to understand whether the level of collaboration can serve as a predictor of four variables measuring professional growth.

The Silicon Valley Math Initiative Mathematics Teaching Rubric (C. A. Dana Center for Mathematics, 2011; Noyce Foundation, 2007) was previously selected as an evaluation instrument for the professional learning program central to this research (see Appendix C). Participating teachers referred to the rubric to self-report on their mathematics practice by underlining words and phrases that best describe their instructional role within the classroom and
selecting an appropriate score. Each category defines four levels of practice, ranging from limited to exemplary teaching, in the following areas:

- Creation and assignment of worthwhile tasks
- Establishing a positive and rigorous learning environment
- Teacher’s role in facilitating mathematics discourse
- Students’ role in mathematics discourse
- Application of tools to enhance discourse
- Analysis of teaching and learning (assessment)

Composite rubric scores range from a minimum of six to a maximum of 24 points, depending on an individual’s self-rating of their mathematics instruction.

While widely used as a tool for professional development, test validity has not been specifically evaluated for the Math Teaching Rubric. The instrument possesses face validity, given that scoring criteria are clearly articulated and represent multiple facets of instructional practice. And, the rubric was developed by a team of subject matter experts from the Noyce Foundation and Silicon Valley Mathematics Initiative, two highly regarded mathematics “think tanks.”

The Math Talk Learning Community Rubric (NCTM, 2004) is a second instrument previously selected to evaluate teachers’ professional growth in mathematics associated with the Abacus program (see Appendix D). The researcher used the instrument when observing participants during math lessons at the beginning and end of the program. As defined, the rubric is designed to assess components of mathematics discourse within individual classrooms (NCTM, 2004). Teacher and student engagement in discourse are measured in four categories:

- Teacher/student involvement in asking questions about mathematics
- Teacher/student role in explaining mathematics thinking
- Teacher/student role as a source of mathematical ideas
- Teacher/student role in assuming responsibility for mathematics learning
Math Talk Rubric category scores range from a minimum of zero, indicating the mathematics learning environment is more traditional, with the teacher as the primary focus, to a maximum of three, indicating the teacher’s actions exemplify a more student-centered classroom.

All observational data collected for this research was gathered by the researcher to ensure consistent application of the Math Talk Rubric. To ensure inter-rater reliability, the researcher pilot tested the rubric in a series of classroom observations while paired with another observer, a local mathematics content expert who designed a series of graduate level mathematics courses focused on content and pedagogy. Table 3, below, provides detail on inter-rater scores collected during the calibration process. Using data from the table, a Fleiss kappa assessment of reliability was calculated with a value of .714, \( p < .001 \) (Fleiss, 1971). The value can be interpreted as substantial inter-rater agreement (Landis & Koch, 1977).

Table 3
Math Talk Rubric Calibration Scores

<table>
<thead>
<tr>
<th>Case</th>
<th>Category 1 Score</th>
<th>Category 2 Score</th>
<th>Category 3 Score</th>
<th>Category 4 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rater X</td>
<td>Rater Y</td>
<td>Rater X</td>
<td>Rater Y</td>
</tr>
<tr>
<td>A</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Similar to the Mathematics Teaching Rubric, the Math Talk Learning Community Rubric has been widely used as a tool for professional development. Given that rubric scoring criteria are clearly articulated and represent multiple facets of a teacher’s role in facilitating mathematics
discourse, the instrument possesses face validity. The Math Talk Learning Community Rubric possesses face validity, given that scoring criteria are clearly articulated and represent multiple facets of instructional practice. Content validity is supported by the fact that the instrument was developed by a panel of experts in mathematics content and instruction (NCTM, 2004).

A third criterion variable was an item from a survey created specifically for Abacus. The Resources and Collaboration Survey instrument prompts participants to identify the number of colleagues who view them as a mathematics leader (see Appendix E). Teachers completed the survey at the beginning and end of the Abacus program. The leadership survey item has intrinsic validity, in that the number of teachers reported directly reflects what the item intends to measure.

The fourth criterion variable addressed in this research was whether participating teachers completed additional coursework, including the development of a web-based portfolio to earn the Mathematics Instructional Added Authorization (MIAA). The added authorization allows a teacher with any California credential to teach mathematics through Algebra I or Integrated Math I in a K-12 classroom setting. The measure for this variable has intrinsic validity, as MIAA completion can be verified through participants’ public credential profile with the California Commission on Teacher Credentialing (CTC). The CTC is a reliable source of information regarding MIAA completion.

**Participant Interviews**

The qualitative data included in this research provided additional insight regarding participants’ perceptions about collaboration throughout the Abacus project and the extent to which collaboration impacted their daily mathematics instructional practice.
Interview Participant Selection: Maxwell (2013) addresses the importance of selecting participants who are heterogeneous but can adequately represent a particular setting. In this case, participants had experience as rural school teachers, and completed the entire Abacus professional learning program. The goal in purposeful sample selection was to interview teachers who shared collaborative experiences and represented different classroom settings as well as varied success in implementing strategies learned during Abacus.

Purposeful sampling is an appropriate strategy to inform the researcher of their “understanding of the research problem and central phenomenon in the study” (Creswell, 2012, p. 81). The researcher considered three factors when purposefully recruiting interview participants. First, the researcher evaluated Abacus completers’ program success, as defined by post-project rubric scores on the Math Talk Learning Community rubric (NCTM, 2004), a tool used for data collection during Abacus project classroom observations. The rubric was selected as an instrument for quantitative data collection with data being evaluated in connection to Research Questions 2a – 2d. For the purpose of selecting potential interview candidates, the researcher evaluated teachers’ post-project rubric scores, which could range from zero – eight (low), nine – 16 (medium), or 17 – 24 (high). Teachers earning high, medium, and low scores were identified as potential interview candidates.

After considering rubric scores, the interviewer considered participants’ background to further ensure variability within the sample. After considering teachers’ grade levels, school type (public, charter, private), in addition to the Math Talk Learning Community rubric score, 10 potential interviewees were recruited via e-mail, with seven accepting the invitation.

Interview Protocol: While participants selected for follow up interviews may have had unique perspectives regarding their collaboration and professional growth, the researcher
anticipated common themes due to the teachers’ shared phenomenological experience in Abacus (Creswell, 2012; McMillan & Schumacher, 2010). The researcher’s interview protocol can be found in Appendix F. The interview process intended to follow up on results of the quantitative research analysis, significant or non-significant, to address questions or themes warranting further investigation.

**Procedures**

**Abacus Professional Learning Program Components**

Program participants were recruited within a region spanning five Northern California counties, with eligible teachers from grades Kindergarten through sixth at rural school sites. Upon meeting eligibility requirements, participants made a commitment to complete a total of 180 hours of professional learning in mathematics content and pedagogy. Two types of meetings comprise the 180 program hours. First, all participants attended whole-group, all-day, centrally located workshops on seven Saturdays and two two-week summer sessions. The whole-group workshops were designed to build a supportive network of elementary math teachers across school, district, and county lines.

The second category of meetings took place in small clusters, with teachers from a single school site or a small group of sites within a five to ten-mile radius. In the small group setting, teachers could collaborate on mathematics instructional practices and curriculum analyses to best meet the needs of their local sites and students. The small cluster meetings were scheduled after teachers’ regular school day at local school sites. Between meeting dates, participants were encouraged to continue collaborative discussions with colleagues, in person or online.

Professional learning included instruction and practice with mathematics content, ranging from number sense to geometry to algebraic thinking, as well as statistics and
probability. Participants had opportunities to collaborate in grade-alike teams to study learning trajectories spanning grades K-8, to better support struggling students as well as those who would benefit from extended learning. Pedagogy was embedded in the program, with participants working in collaborative groups, discovering and practicing multiple strategies for engaging all students in mathematics. In addition, the program included a curriculum component with participants analyzing and sharing resources from their own sites, completing a lesson study, and later designing standards based, inquiry-focused project-based mathematics units. A final component was leadership development, intended to support participating teachers as they share their knowledge in support of their colleagues in the local school community. Abacus participants had the option of completing an additional 45 hours of mathematics coursework to earn a MIAA certification.

**Role of the Researcher**

The researcher in this dissertation study previously served as Abacus program manager and was the primary facilitator for after-school and Saturday professional learning sessions. In addition, while serving as program manager, the researcher was solely responsible for collecting data required for program evaluation.

The researcher’s responsibility with new data collection included contact with all participants via e-mail to explain the nature of this study as an extension of prior Abacus program evaluation, and to obtain informed consent for additional data gathering. Next, the researcher met with seven program participants, individually at their respective school sites, for follow up interviews.
Data Collection

This research intended to further explore results from a recently completed mathematics professional learning program for which evaluation data was previously collected. In addition to secondary analysis of selected information collected before December, 2017, Table 4 outlines the timeline for gathering quantitative and qualitative information from participating teachers.

Table 4
Data Collection

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Data Source</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>July, 2016</td>
<td><em>Collection During Abacus</em>: Silicon Valley Math Initiative Mathematics Teaching Rubric</td>
<td>Paper and pencil, teacher self-reporting per the rubric, completed during the first day of the program’s Summer Institute.</td>
</tr>
<tr>
<td>July, 2016</td>
<td><em>Collection During Abacus</em>: Resources and Collaboration Survey, Section C, Number of teachers viewing the participant as a leader</td>
<td>Paper and pencil survey, completed during the first day of the program’s Summer Institute.</td>
</tr>
<tr>
<td>September, 2017</td>
<td><em>Collection During Abacus</em>: Resources and Collaboration Survey, Section C, Number of teachers viewing the participant as a leader</td>
<td>Paper and pencil survey, completed during a whole-group Saturday meeting coinciding with the beginning of the school year.</td>
</tr>
<tr>
<td>November, 2017</td>
<td><em>Collection During Abacus</em>: Silicon Valley Math Initiative Mathematics Teaching Rubric</td>
<td>Paper and pencil, teacher self-reporting per the rubric, completed during the program’s final Saturday workshop.</td>
</tr>
</tbody>
</table>
(Table 4 Continued)

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Data Source</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>April, 2018</td>
<td><em>Collection During Abacus</em>: Mathematics Instructional Added Authorization (MIAA), program completed.</td>
<td>Review of participant website links for completed portfolios, and review of CTC website to confirm authorization processing.</td>
</tr>
<tr>
<td>November, 2018</td>
<td><em>New</em>: Teacher Collaboration Assessment Rubric Survey (Gadja &amp; Koliba, 2008; Lehman, Kim, &amp; Harris, 2014; Zito, 2011).</td>
<td>Online survey, participants contacted via e-mail to explain the purpose and procedures for survey completion.</td>
</tr>
<tr>
<td>November, 2018 and December, 2018</td>
<td><em>New</em>: Participant in-person interviews.</td>
<td>Individual interviews were pre-scheduled by the researcher and were audio-recorded.</td>
</tr>
</tbody>
</table>

**Data Analysis**

**Researcher Bias**

Given ongoing association with the two-year professional learning program, the researcher established a professional working relationship with program participants, creating potential bias. Creswell (2012, p. 81) states researchers must, “bracket out, as much as possible, their own experiences.” In this study, care was necessary to ensure the researcher’s personal opinions did not interfere with analysis of interview data. The researcher kept a record of ethical considerations throughout data collection and analysis, tracking potential issues and her rationale for making decisions connected to this research (McMillan & Schumacher, 2010). In addition, while interpreting interview data, the researcher practiced regular reflection to examine positionality as a form of critical reflexivity (Creswell, 2012; McMillian & Schumacher, 2010). Following initial evaluation and coding of interview data, the researcher selected a colleague not
connected with Abacus or this study to serve as a peer debriefer. The peer debriefer reviewed interview transcriptions and the researcher’s analysis to identify threats to objectivity (McMillan & Schumacher, 2010) with potential threats documented in the ethical considerations log.

**Quantitative Data Analysis**

Survey data were analyzed to determine whether there are correlations between teacher perceptions about collaboration during professional learning and multiple measures of professional growth as mathematics educators. Variables linked to teacher collaboration were defined as predictors. Data associated with teacher practice (observed and self-rated), MIAA program completion, and teacher leadership were defined as criterion variables. Owing to the retrospective reporting on quality of collaboration and correlational design being employed, caution was given in considering any causal conclusions. Hence, the researcher employed the labels “predictor and criterion variables” rather than “independent and dependent variables” which seemed more suitable. However, the underlying logic was that the quality of collaboration not only predicts, but may be impacting, professional growth.

Hierarchical regression analysis was used to evaluate possible correlations between collaboration and professional growth. Given the exploratory nature of this study, that the small sample size of 38, and considering limited statistical power, the researcher used an alpha of .10 for data analysis. However, to control for the Type 1 error rate across related sets of analyses, a Bonferroni adjustment was also be made. For example, Research Question #1 has four subparts (corresponding to the four types of collaboration subscales), so the adjusted alpha is .10/4 = .025.

Table 5, below, provides a template for presenting the results of the hierarchical regression analysis used in addressing the first subpart of the first research question:
After controlling for teachers’ initial self-reported rating of the quality of their daily mathematics instructional practice, to what extent can variation in their self-reported rating of the quality of their daily mathematics instructional practice, reported at the end of the two-year Abacus program, be accounted for by their perceptions of the quality of program collaboration as indicated by structured opportunities for dialogue between program participants?

The change in $R^2$ associated with Block 2 quantified the proportion of variance in the criterion variable accounted for by the indicator of collaboration quality. The sign on the regression coefficient for the collaboration quality predictor variable determined whether it is positively or negatively associated with the criterion; it is hypothesized to be a positive relationship, given that both the predictor and criterion variables use higher scores to indicate more desirable processes and outcomes.

Table 5

Research Question 1a, results from hierarchical regression of self-reported mathematics instructional practice on quality of program collaboration as indicated by structured opportunities for dialogue between program participants, controlling for initial level of self-reported mathematics instructional practice

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td></td>
</tr>
<tr>
<td>Block 2: Collaboration, Dialogue</td>
<td></td>
</tr>
</tbody>
</table>

Note. Regression coefficients are based on the final full model. *$p<.10$, **$p<.025$
Similarly formatted tables are used to present the results where the criterion variable was teachers’ self-evaluation of their mathematical practice and the indicators of collaboration quality focused on the role of teamwork in decision making, action in application of knowledge and decisions in daily classroom practice, and reflection on teaching practice to improve instruction (i.e., evaluation). In other words, the specific variable added in Block 2 changes to another aspect of collaboration.

To address Research Question 2a, 2b, 2c, and 2d, another set of four tables have been created, using the format found in Table 5, above. The criterion variable changes to observational data focused on teachers’ facilitation of mathematical discourse but the aspects of collaboration quality remain the same predictors mentioned above.

To address Research Question 3a, 3b, 3c, and 3d, another set of four tables have been created, using the format found in Table 5, above. The criterion variable changes to leadership (as indicated by the number of colleagues who viewed the teacher as a school-site mathematics leader) but the aspects of collaboration quality remain the same predictors mentioned above.

To address Research Question 4a, 4b, 4c, and 4d, multiple linear regression was not used, as the criterion variable is not continuous, but a dichotomy (earned or did not earn the MIAA-Mathematics Instructional Added Authorization- certification). While logistic regression could be utilized, in a manner similar to the approach taken above, independent-samples t-tests have been used to determine if the quality of collaboration, on average, differs between those who did and did not earn a MIAA certification. The results for all four indicators of collaboration are presented in a format and illustrated in Table 6, below.
Table 6
Descriptive statistics and independent-samples t-test results comparing quality of collaboration for those who did and did not earn a MIAA certification

<table>
<thead>
<tr>
<th>Collaboration Quality Indicator</th>
<th>Completed MIAA</th>
<th>Did Not Complete MIAA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>a) Dialogue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Decision-Making</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Taking Action</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Evaluation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .10; **p < .025

Qualitative Data Analysis

Audio recordings of individual teacher interviews have been transcribed for evaluation purposes and were reviewed several times to identify patterns and commonalities among participants’ experiences and perceptions about collaboration during the Abacus project (Creswell, 2012). Patterns and phrases were coded, with attributes categorized into a series of themes (Glaser and Strauss, 1967).

Assumptions and Limitations

The researcher’s dual role as professional learning facilitator and primary data collector was a potential source of bias in this study. Creswell (2012) cautions researchers to exercise care, ensuring that their personal opinions do not interfere with analysis of data. Throughout data analysis, the researcher practiced regular reflection during the interpretation of participants’
responses. When interpreting interview data, care was given to the purposeful repeated reading of participants’ comments to focus on their accurate intent and meaning.

Limitations

There are limitations connected with this study, given that it was connected with a specially designed professional learning program serving a specific group of teachers from local rural communities. From a qualitative standpoint, interviews of a subset of seven participants is more than adequate to study a phenomenology of the specific group’s shared experience as collaborators in Abacus (Creswell, 2012). However, there are concerns regarding quantitative data collected for the entire teacher sample ($n = 38$) and generalizability of results beyond the program participant group (McMillan and Schumacher, 2010).

Subject effects is a threat to internal validity when research participants change their behavior because they know they are being studied (McMillan & Schumacher, 2010). Subject effects were a concern during this study, since participating teachers may have wanted to create a positive impression with one another and/or those facilitating the professional development program. The use of anonymous surveys was a strategy to control for this threat.

Pretesting was another potential threat to internal validity, as several instruments were used more than once to survey teachers at the beginning and end of the Abacus program. For example, participants used the Mathematics Teaching Rubric several times to evaluate their practice, and the Resources and Collaboration Survey was completed at different intervals as a tool to measure growth. McMillian and Schumacher (2010) explain that a participant’s mere access to an assessment tool might be enough to change attitudes over time, regardless of the treatment experienced during the research period.
As noted by McMillian and Schumacher (2010), maturation is another potential threat to validity, given that participants were involved in a professional learning program spread over the course of two school years. Despite potential benefits from the professional learning program and resulting change in one’s professional growth, teachers’ practice may have improved regardless, as a result of adding two years of classroom experience and all that may be learned as a result of spending time in the classroom.

Abacus participants earned up to $4000.00 in stipends for their participation in 180 hours of workshops and meetings required for the program. The use of convenience sampling, where participants were exclusively the set of teachers who applied to be involved with the program, is a factor further limiting the generalizability of any findings to the greater population of teachers. However, considering the lack of prior research regarding schools and teachers in rural communities, this study is a positive step in gaining additional understanding of education in the targeted setting.
CHAPTER 4: RESULTS

As stated in Chapter One, this study explored the extent to which teachers’ perceptions about their opportunities to collaborate with peers during the Abacus program were related to their professional growth as mathematics educators and to better understand the nature of any association. This chapter is organized with an introduction, providing descriptive statistics to revisit participant demographics and the analysis of the Teacher Collaboration Assessment Survey (TCAS), the measurement instrument used in research questions one through four. Following the introduction, results are organized and presented, in order, for each of the five research questions central to this mixed methods study. Hierarchical regression analysis was used for research questions one through three, and independent samples t-test results are presented for research question four. Qualitative analysis of participant interview data is summarized for research question five, providing additional insight to quantitative data collected during this study.

Quantitative Data

Participants

As noted in Chapter Three, the Abacus mathematics professional learning program served 38 teachers from K-8 rural schools in Northern California. Participants represented a range of teaching experience from one to 44 years, and they worked in a variety of settings: public, public charter, and private school sites.

Following conclusion of the two-year professional learning program, every Abacus participant was contacted through a series of e-mails to complete the TCAS. A three-week e-mail recruitment effort yielded survey responses from 33 program participants whose identities are anonymous. Participants responding to the online TCAS questionnaire used a three-digit
Abacus program identification number previously assigned to them, allowing the researcher to pair collaboration survey data with other data gathered during the professional learning program.

**Teacher Collaboration Assessment Survey (TCAS)**

As stated in Chapter Three, prior evaluation of the TCAS instrument’s internal consistency yielded Cronbach alpha reliability coefficients, of the scale overall, of .92 and .93, respectively (Lehman, Kim, & Harris, 2014; Zito, 2011). Lehman, Kim, and Harris (2014) additionally addressed Cronbach reliability coefficients for the four collaboration categories: dialogue = .72; decision making = .79; action = .74; and, evaluation = .75.

Participants in this dissertation study completed an online survey modeled after the TCAS, with minor formatting changes to include the names of Abacus program components. Analysis of internal consistency reliability resulted in Cronbach alpha coefficients as follows, for each of the four collaboration categories: dialogue = .85; decision-making = .79; action = .72; and, evaluation = .77. Cronbach alpha coefficients are closely aligned with reliability findings in prior research, and as indicated by McMillan and Schumacher (2010), values in excess of .70 are generally accepted as reliable.

Survey data were analyzed to determine whether there were correlations between teacher perceptions about collaboration during professional learning and multiple measures of professional growth as mathematics educators. Variables linked to teacher collaboration were defined as predictors, and data associated with teacher practice (observed and self-rated), MIAA program completion, and teacher leadership were defined as criterion variables.

Hierarchical regression analysis was used to evaluate possible correlations between collaboration and professional growth. Given the exploratory nature of this study, that the sample size of 38 is small, and the statistical power is limited, the Type I Error rate, $\alpha$, was set to
.10 for data analysis. However, to control for the error rate across related sets of analyses, a Bonferroni adjustment was also made. For example, Research Question #1 has four subparts (corresponding to the four types of collaboration subscales) so the adjusted alpha was \( .10 / 4 = .025 \).

**Research Question One: Self-Reported Instructional Practice**

After controlling for teachers’ initial self-reported rating of the quality of their daily mathematics instructional practice, to what extent can variation in their self-reported rating of the quality of their daily mathematics instructional practice, reported at the end of the two-year professional learning program, be accounted for by their perceptions of the quality of program collaboration as indicated by:

a) Structured opportunities for dialogue between program participants?
b) The role of teamwork in decision making?
c) Action in application of knowledge and decisions in daily classroom practice?
d) Evaluation - reflection on teaching practice to improve instruction?

**Results Addressing Research Question One**

To address RQ1, a series of four hierarchical multiple linear regression analyses were conducted. Block 1 controls for participants’ initial level (2016) of self-reported mathematical instructional practice. In the first analysis, Block 1, the initial teacher self-report regarding their teacher practice was used as the first predictor, explaining one-third of the variation \( (R^2 = .333) \) in their post-project (2017) self-reports \( (b = .563, \beta = .577, t(28) = 3.737, p = .001) \).

Next, after controlling for participants’ initial level of self-reported mathematics instructional practice, RQ1 sub-questions (a, b, c, and d) address four collaboration components, as defined in the Teacher Collaboration Assessment Survey (TCAS): dialogue, decision-making, action-taking, and reflective evaluation (Gadja & Koliba, 2017). Hierarchical regression data for the four survey subscales are presented in Tables 7, 8, 9, and 10.
Table 7 reflects results from hierarchical regression of self-reported mathematics instructional practice on the quality of program collaboration, as indicated by structured opportunities for dialogue between program participants, controlling for the initial level of self-reported mathematics instructional practice. Following Block 1 analysis, data for the TCAS subscale, collaborative dialogue, was entered, explaining an additional 4.2% of data variation ($\Delta R^2 = .042$).

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Self-Evaluation of Mathematics Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.597</td>
</tr>
<tr>
<td>Block 2: Collaboration, Dialogue</td>
<td>-.243</td>
</tr>
</tbody>
</table>

*Note. Regression coefficients are based on the final full model. *$p<.10$; **$p<.025$*

Of note is the negative regression coefficient for the collaboration variable, dialogue, indicating that as structured opportunities for dialogue between program participants increased, teachers reported lower quality mathematics instructional practice, once adjusted for initial levels. However, dialogue was not a statistically significant predictor of the change in self-reported practice ($b = -.243$, $\beta = -.207$, $t(27) = -1.339$, $p = .192$) suggesting that the unexpected pattern observed in this sample is not necessarily a reliable one that would be expected if the study were to be replicated.
In Table 8, hierarchical regression data are presented relative to the quality of program collaboration, as indicated by structured opportunities for decision-making between program participants, controlling for the initial level of self-reported mathematics instructional practice. The TCAS subscale decision-making was entered, explaining an additional 8.6% of the variation ($\Delta R^2 = .086$). A negative regression coefficient for the collaboration variable, decision-making, indicates that as structured opportunities for decision-making between program participants increases, teachers report lower quality mathematics instructional practice, once adjusted for initial levels. Further, considering its p-value of .056, an argument could be made that decision-making, is a statistically significant predictor for participating teachers’ self-evaluation of their mathematics teaching practice ($b = -.360, \beta = -.294, t(27) = -2.000, p = .056$). However, particularly once the Bonferroni correction is applied, with alpha at .025 rather than .10, it is recognized that this relationship may be the result of sampling error rather than a real association.

Table 8

**RQ 1b, Hierarchical regression analyses for self-evaluation of mathematics practice and collaborative decision-making**

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Self-Evaluation of Mathematics Practice</th>
<th>$b$</th>
<th>$SE_b$</th>
<th>$\beta$</th>
<th>$t$</th>
<th>sig.</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 1: Initial Level</td>
<td></td>
<td>.569</td>
<td>.143</td>
<td>.583</td>
<td>3.973</td>
<td>**.001</td>
<td>.333</td>
<td></td>
</tr>
<tr>
<td>Block 2: Collaboration, Decision-Making</td>
<td></td>
<td>-.360</td>
<td>.180</td>
<td>-.294</td>
<td>-2.000</td>
<td>.056</td>
<td>.419</td>
<td>.086</td>
</tr>
</tbody>
</table>

Note. Regression coefficients are based on the final full model. *$p<.10$; **$p<.025$
Table 9 displays data resulting from the hierarchical regression of self-reported mathematics instructional practice on the quality of program collaboration, as indicated by taking action in application of knowledge and decisions in daily classroom practice, controlling for the initial level of self-reported mathematics instructional practice. When entered as a block two variable, action accounts for .6% of the variation ($\Delta R^2 = .006$).

Table 9

\textit{RQ 1c, Hierarchical regression analyses for self-evaluation of mathematics practice and collaborative action}

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Self-Evaluation of Mathematics Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.592</td>
</tr>
<tr>
<td>Block 2: Collaboration, Action</td>
<td>.546</td>
</tr>
</tbody>
</table>

\textit{Note.} Regression coefficients are based on the final full model. *$p<.10$; **$p<.025$}

The regression coefficient is positive for the variable, action, which, had it been significant would suggest that the more teachers report that collaboration results in taking action in applying knowledge and making decisions about daily classroom practice, the higher are teachers’ self-reported mathematics instructional practice, after controlling for initial levels. However, the variable, action, is not a statistically significant predictor of participants’ self-reported mathematics teaching practice ($b = .546$, $\beta = .076$, $t(27) = .432$, $p = .671$).

Finally, Table 10 presents data resulting from the hierarchical regression of self-reported mathematics instructional practice on the quality of program collaboration, as indicated by structured opportunities for reflective evaluation by program participants, controlling for the
initial level of self-reported mathematics instructional practice. The TCAS collaboration subscale, reflective evaluation, was entered, accounting for an additional 9.1% of data variation ($\Delta R^2 = .091$). Given its p-value of .049, the factor decision-making, was initially a statistically significant predictor for participating teachers’ self-evaluation of their mathematics teaching practice.

Table 10
*RQ 1d, Hierarchical regression analyses for self-evaluation of mathematics practice and reflective evaluation*

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Self-Evaluation of Mathematics Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.597</td>
</tr>
<tr>
<td>Block 2: Collaboration, Evaluation</td>
<td>-.282</td>
</tr>
</tbody>
</table>

*Note.* Regression coefficients are based on the final full model. *$p<.10$; **$p<.025$*

The regression coefficient is negative for the variable, evaluation, which suggests that the more teachers report that collaboration occurs by structured opportunities for reflective evaluation, the lower are teachers’ self-reported mathematics instructional practice, after controlling for initial levels ($b = -.282, \beta = -.303, t(27) = -2.061, p = .049$). However, following a Bonferroni adjustment, the variable, evaluation, is not statistically significant.

**Summary for Research Question One**

Hierarchical regression analyses were completed for teacher self-reported rubric scores collected through the Silicon Valley Math Initiative (SVMI) Mathematics Teaching Rubric (controlling for initial self-reported perceptions) and participant responses to the Teacher
Collaboration Assessment Rubric (TCAR) survey. Two collaboration factors, decision-making ($p = 0.56$) and evaluation ($p = 0.049$) were initially found to be significant predictors of Abucs participants’ self-reported instructional practice. Following a Bonferroni correction where alpha was adjusted to 0.025, neither factor remained statistically significant.

**Research Question Two: Observed Practice in Facilitating Mathematics Discourse**

After controlling for the total initial rubric score connected with the observation of teachers’ roles in facilitating student-led mathematics discourse (questioning, explaining, source of ideas, and taking responsibility for learning), to what extent can variation in the total rubric score connected with the observation of teachers’ role in facilitating student-led mathematics discourse, reported at the end of the two-year professional learning program, be accounted for by teachers’ perceptions of the quality of program collaboration as indicated by:

a) Structured opportunities for dialogue between program participants?  
b) The role of teamwork in decision making?  
c) Action in application of knowledge and decisions in daily classroom practice?  
d) Evaluation - reflection on teaching practice to improve instruction?

**Results Addressing Research Question Two**

In addressing RQ2, a series of four hierarchical multiple linear regression analyses were conducted. Block 1 controls for participants’ initial Math Talk Learning Community (NCTM, 2004) rubric score based on classroom observations completed at the beginning of the Abacus project. Each participant’s score was a final summation of subscores several discourse categories (questioning, explaining, source of ideas, and taking responsibility for learning). In the first analysis, the rubric score (from 2016), used as the first predictor, explained one-half of the variation ($R^2 = .501$) in participants’ post-project (2017) observation scores ($b = .588$, $\beta = .708$, $t(28) = 4.131$, $p = .001$).
Next, after controlling for participants’ initial rubric scores, RQ2 sub-questions (a, b, c, and d) address four collaboration components, as defined in the Teacher Collaboration Assessment Survey (TCAS); dialogue, decision-making, action-taking, and reflective evaluation (Gadja & Koliba, 2017). Hierarchical regression data for the four survey subscales are presented in Tables 11, 12, 13, and 14.

Table 11 presents results from hierarchical regression of participants’ role as facilitators of student-led mathematics discourse, denoted by a rubric score, on the quality of program collaboration, as indicated by structured opportunities for dialogue between program participants, controlling for the initial level of mathematics discourse facilitation. Block 2 analysis for the TCAS subscale, collaborative dialogue, was entered, accounting for an additional .1% of data variation ($\Delta R^2 = .001$).

Table 11
*RQ 2a, Hierarchical regression analyses for observed practice in facilitating discourse and collaborative dialogue*

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.582</td>
</tr>
<tr>
<td>Block 2: Collaboration, Dialogue</td>
<td>.184</td>
</tr>
</tbody>
</table>

Note. Regression coefficients are based on the final full model. *$p<.10$; **$p<.025$*

The regression coefficient for the collaboration variable, dialogue, is positive, indicating a positive association with observed practice in facilitating discourse. However, dialogue was not a statistically significant predictor variable ($b = .184$, $\beta = .026$, $t(27) = .140$, $p = .890$).
Table 12 displays hierarchical regression of participants’ role as facilitators of student-led mathematics discourse, denoted by their total rubric score, on the quality of program collaboration, as indicated by structured opportunities for decision-making between program participants, controlling for the initial level of mathematics discourse facilitation. The second TCAS subscale, decision-making, explains an additional 3.4% of the variation ($\Delta R^2 = .034$).

Table 12

RQ 2b, Hierarchical regression analyses for observed practice in facilitating discourse and collaborative decision-making

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.626</td>
</tr>
<tr>
<td>Block 2: Collaboration, Decision-Making</td>
<td>-1.302</td>
</tr>
</tbody>
</table>

*Note. Regression coefficients are based on the final full model. *$p<.10$; **$p<.025$*

The regression coefficient for decision-making is positive, suggesting a positive association with observed practice in facilitating discourse. The variable, decision-making, however, was not a statistically significant predictor ($b = -1.302, \beta = 1.211, t(27) = -1.075, p = .298$).

Presented in Table 13 are the hierarchical regression results of participants’ role as facilitators of student-led mathematics discourse, denoted by their total rubric score, on the quality of program collaboration, as indicated by structured opportunities for participants to take action, controlling for the initial level of observed mathematics discourse facilitation.
The third TCAS subscale, action-taking, was entered as a Block 2 variable, explaining an additional .6% of the variation ($\Delta R^2 = .006$).

Table 13
**RQ 2c, Hierarchical regression analyses for observed practice in facilitating discourse and collaborative action-taking**

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.592</td>
</tr>
<tr>
<td>Block 2: Collaboration, Action</td>
<td>.546</td>
</tr>
</tbody>
</table>

*Note. Regression coefficients are based on the final full model. *$p<.10$; **$p<.025$*

The regression coefficient for collaborative action is positive, indicating a positive association with observed practice in facilitating discourse. However, the variable, action, was not a statistically significant predictor of teachers’ observed practice in facilitating mathematics discourse ($b = .546, \beta = 1.263, t(27) = .076, p = .671$).

Table 14 presents the final set of data for RQ2, displaying the results of hierarchical regression of participants’ role as facilitators of student-led mathematics discourse, denoted by their rubric score, on the quality of program collaboration, as indicated by structured opportunities for reflective evaluation, controlling for the initial level of mathematics discourse facilitation. The Block 2 variable, evaluation, was entered, explaining an additional 1% of data variation ($\Delta R^2 = .010$).
Table 14

RQ 2d, Hierarchical regression analyses for observed practice in facilitating discourse and reflective evaluation

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.582</td>
</tr>
<tr>
<td>Block 2: Collaboration, Evaluation</td>
<td>.434</td>
</tr>
</tbody>
</table>

Note: Regression coefficients are based on the final full model. *p<.10; **p<.025

A positive regression coefficient for collaborative action indicates a positive association with observed practice in facilitating discourse. However, reflective evaluation was not a statistically significant predictor variable (b = 434, β = .100, t(27) = .572, p = .575).

Summary for Research Question Two

Hierarchical regression analyses were completed for participants’ role as facilitators of student-led mathematics discourse collected through classroom observations and using the NCTM (2004) Math Talk Learning Community Rubric (controlling for initial observed practice rubric scores) and participant responses to the Teacher Collaboration Assessment Rubric (TCAR) survey. None of the four key collaboration factors, addressed in the TCAR (dialogue, teamwork in decision making, action-taking, and evaluation) were statistically significant predictors of Abacus participants’ observed practice in facilitating student-led mathematics discourse, once initial levels of this skill were controlled.

Research Question Three: Role as a Mathematics Leader

After controlling for the initial number of colleagues who viewed the teacher as a school-site mathematics leader, to what extent can variation in the number of colleagues who viewed the
teacher as a school-site mathematics leader, reported at the end of the two-year professional learning program, be accounted for by their perceptions of the quality of program collaboration as indicated by:

a) Structured opportunities for dialogue between program participants?
b) The role of teamwork in decision making?
c) Action in application of knowledge and decisions in daily classroom practice?
d) Evaluation - reflection on teaching practice to improve instruction?

Results Addressing Research Question Three

RQ3 involves a series of four hierarchical multiple linear regression analyses with Block 1 controlling for participants’ initial leadership role, reported at the beginning of the Abacus project, as indicated by the number of colleagues who viewed the teacher as a school-site mathematics leader. In the first analysis, the number of colleagues supported (in 2015) was used as the first predictor, explaining 3% of the variation ($R^2 = .030$) in participants’ post-project (2017) leadership roles, again, indicated by the number of colleagues who viewed the teacher as a school-site mathematics leader ($b = .328, \beta = .174, t(29) = .951, p = .349$).

In the next step, after controlling for participants’ initial leadership, RQ3 sub-questions (a, b, c, and d) address four collaboration components, as defined in the Teacher Collaboration Assessment Survey (TCAS); dialogue, decision-making, action-taking, and reflective evaluation (Gadja & Koliba, 2017). Hierarchical regression data for the four survey subscales are presented in Tables 15, 16, 17 and 18.

Data presented in Table 15 reflects results from hierarchical regression of leadership on the quality of program collaboration, as indicated by structured opportunities for dialogue between program participants, controlling for the initial level of leadership. Block 2 analysis for the TCAS subscale, collaborative dialogue, was entered, explaining an additional 6.8% of data variation ($\Delta R^2 = .068$).
Table 15
RQ 3a, Hierarchical regression analyses for mathematics leadership and collaborative dialogue

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.372</td>
</tr>
<tr>
<td>Block 2: Collaboration, Dialogue</td>
<td>1.649</td>
</tr>
</tbody>
</table>

Note. Regression coefficients are based on the final full model. *p<.10; **p<.025

The regression coefficient for collaborative dialogue is positive, indicating a positive association with mathematics leadership. However, the variable, dialogue, was not a statistically significant predictor ($b = 1.649$, $\beta = .261$, $t(28) = 1.448$, $p = .159$).

Table 16 displays results from hierarchical regression of leadership on the quality of program collaboration, as indicated by structured opportunities for decision-making between program participants, controlling for the initial level of leadership. Analysis for the second TCAS subscale, decision-making, was entered, accounting for an additional .7% of data variation ($\Delta R^2 = .007$).
Table 16
RQ 3b, Hierarchical regression analyses for mathematics leadership and collaborative decision-making

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[b, SE_b, β, t, sig, R^2, ΔR^2]</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>[.328, .349, .174, .939, .356, .030]</td>
</tr>
<tr>
<td>Block 2: Collaboration, Decision-Making</td>
<td>[.540, 1.217, .082, .444, .661, .037, .007]</td>
</tr>
</tbody>
</table>

*Note. Regression coefficients are based on the final full model. *p<.10; **p<.025

The regression coefficient is positive for decision-making, suggesting a positive association with mathematics leadership. Decision-making, however, was not a statistically significant predictor variable (b = .540, β = .082, t(28) = .444, p = .661).

Table 17 presents hierarchical regression data analyses for leadership on the quality of program collaboration, as indicated by structured opportunities for collaborative action, controlling for participants’ initial level of leadership. Data for the third TCAS subscale, action-taking, was entered as a variable in Block 2 and accounts for an additional .2% of data variation (ΔR^2 = .002).
Table 17

*RQ 3c, Hierarchical regression analyses for mathematics leadership and collaborative action-taking*

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.318</td>
</tr>
<tr>
<td>Block 2: Collaboration, Action</td>
<td>.272</td>
</tr>
</tbody>
</table>

*Note.* Regression coefficients are based on the final full model. *$p < .10$; **$p < .025$*

The regression coefficient for action-taking is positive, indicating a positive association with mathematics leadership. The variable, action, was not a statistically significant predictor ($b = .272, \beta = .040, t(28) = .214, p = .832$).

Finally, Table 18 displays results from hierarchical regression of leadership on the quality of program collaboration, as indicated by structured opportunities for reflective evaluation by program participants, controlling for the initial level of leadership. Data for the fourth TCAS subscale, reflective evaluation, was entered as a second step of analysis and explains an additional 12.8% of data variation ($\Delta R^2 = .128$).
Table 18
RQ 3d, Hierarchical regression analyses for mathematics leadership and reflective evaluation

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Criterion: Observed Practice in Facilitating Discourse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td>Block 1: Initial Level</td>
<td>.227</td>
</tr>
<tr>
<td>Block 2: Collaboration, Evaluation</td>
<td>1.764</td>
</tr>
</tbody>
</table>

Note: Regression coefficients are based on the final full model. *p<.10; **p<.025

A positive regression coefficient for reflective evaluation indicates a positive association with mathematics leadership. In other words, the more teachers report that collaboration occurs by structured opportunities for reflective evaluation, the higher number of colleagues at their school site they self-report to be viewed by as a mathematics education leader, after controlling for initial levels. Reflective evaluation was a statistically significant predictor variable \( b = 1.764, \beta = .361, t(28) = 2.060, p = .049 \) before applying the Bonferroni adjustment, but would not be considered significant once the correction is made.

Summary for Research Question Three

Hierarchical regression analyses were completed to study variation in the number of colleagues who viewed the teacher as a school-site mathematics leader (controlling for the initial number reported at the beginning of Abacus) and participant responses to the Teacher Collaboration Assessment Rubric (TCAR) survey. One collaboration factor, evaluation \( (p = .049) \) was initially found to be a significant predictor of Abacus participants’ self-reported mathematics leadership. Following a Bonferroni correction where alpha was adjusted to 0.025, none of the four key collaboration factors addressed in the TCAR (dialogue, teamwork in
decision making, action-taking, and evaluation) were statistically significant predictors of Abacus participants’ role as a school-site mathematics leader.

**Research Question Four: Mathematics Instructional Added Authorization Completion**

a) Is there a difference in the average perceptions of quality of program collaboration, as indicated by structured opportunities for dialogue between program participants, between program participants who did and did not earn their Mathematics Instructional Added Authorization?

b) Is there a difference in the average perceptions of quality of program collaboration, as indicated by the role of teamwork in decision making, between program participants who did and did not earn their Mathematics Instructional Added Authorization?

c) Is there a difference in the average perceptions of quality of program collaboration, as indicated by application of knowledge and decisions in daily classroom practice, between program participants who did and did not earn their Mathematics Instructional Added Authorization?

d) Is there a difference in the average perceptions of quality of program collaboration, as indicated by reflection on teaching practice to improve instruction, between program participants who did and did not earn their Mathematics Instructional Added Authorization?

**Results for Research Question Four**

Independent-samples t-tests were used to determine whether the quality of collaboration, on average, differed among Abacus program participants who did and did not earn a Mathematics Instructional Added Authorization (MIAA) certification. The results for all four indicators of collaboration (dialogue, decision-making, action, and evaluation) are presented in Table 19 below.

As noted in the table, independent-samples t-test comparing the quality of collaboration for each TCAS subscale suggests there are no significant differences in participants’ perceptions about the components of Abacus program between those who completed the MIAA certification and those who did not complete MIAA.
Table 19

*RQ 4, Independent-samples t-test results comparing collaboration for MIAA completers and non-completers*

<table>
<thead>
<tr>
<th>Collaboration Quality Indicator</th>
<th>Completed MIAA ( n = 11 )</th>
<th>Did Not Complete MIAA ( n = 22 )</th>
<th>( t )</th>
<th>( p )</th>
<th>( \beta )</th>
<th>( \Delta R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Dialogue</td>
<td>4.69 (.333)</td>
<td>4.60 (.438)</td>
<td>.583</td>
<td>.564</td>
<td>.104</td>
<td>.011</td>
</tr>
<tr>
<td>b) Decision-Making</td>
<td>4.57 (.366)</td>
<td>4.63 (.398)</td>
<td>-.391</td>
<td>.698</td>
<td>.070</td>
<td>.005</td>
</tr>
<tr>
<td>c) Action</td>
<td>4.53 (.454)</td>
<td>4.61 (.343)</td>
<td>-.645</td>
<td>.524</td>
<td>.115</td>
<td>.013</td>
</tr>
<tr>
<td>d) Evaluation</td>
<td>4.53 (.361)</td>
<td>4.32 (.568)</td>
<td>1.109</td>
<td>.276</td>
<td>.195</td>
<td>.038</td>
</tr>
</tbody>
</table>

*Note. \( p < .10 \) (2-tailed t-test, alpha = .10.)*

As noted in Table 19, above, there was not a significant difference in collaborative dialogue when comparing perceptions among program participants who completed the MIAA certification (\( M = 4.69, SD = .333 \)) and those who did not complete the MIAA (\( M = 4.60, SD = .438 \)); \( t(31) = .583, p = .564 \). Independent-samples t-test results for decision-making, the second TCAS subscale, were not significant when comparing perceptions for MIAA completers (\( M = 4.57, SD = .366 \)) and non-completers (\( M = 4.63, SD = .398 \)); \( t(31) = -.391, p = .698 \). Results are also non-significant when comparing perceptions about collaborative action-taking among participants completing the MIAA (\( M = 4.53, SD = .454 \)) and MIAA non-completers (\( M = 4.61, SD = .343 \)); \( t(31), p = .524 \). And in the final TCAS subcategory, evaluation, independent-samples t-test results did not show a significant difference when comparing MIAA completers (\( M = 4.53, SD = .361 \)) and non-completers (\( M = 4.32, SD = .568 \)); \( t(31), p = .276 \).
Summary for Research Question Four

An independent-samples t-test was completed to study variation in participant responses to the Teacher Collaboration Assessment Rubric (TCAR) survey among Abacus participants who completed additional coursework to earn MIAA certification, versus those who did not. When evaluating the key collaboration components (dialogue, teamwork in decision making, action-taking, and evaluation) the independent-samples t-test suggested there are no significant differences in participants’ perceptions about the components of Abacus program among those who completed the MIAA certification and those who did not complete MIAA.

Summary for All Research Questions Utilizing Quantitative Data

Table 20 below summarizes the results for Research Questions One through Four involving quantitative data. None of the collaboration components remained statistically significant after applying the Bonferroni correction (with alpha= .025) within each set of four related analyses per research question. However, given the small sample size and exploratory nature of this study, it is worth recognizing the three combinations where significance was initially found (using alpha = .10): collaborative decision-making and collaborative evaluation as predictors for teacher self-reports of their instructional practice, and, collaborative evaluation as a predictor of teachers being viewed as a mathematics leader.

Also noteworthy is the proportion of additional variance explained ( $\Delta R^2$ ) after controlling for initial levels: 8.6% for collaborative decision-making and teachers’ self-reported instructional practice, 9.1% for collaborative evaluation and teachers’ self-reported instructional practice, and finally, 12.8% for collaborative evaluation and teachers’ mathematics leadership.
Table 20
Summary of Quantitative Data Analyses

<table>
<thead>
<tr>
<th>TCAS Collaboration Quality Indicator</th>
<th>RQ1 Teacher’s Self-Evaluation of Own Mathematical Practice</th>
<th>RQ2 Observation of Teacher’s Role in Facilitating Student Discourse</th>
<th>RQ3 Teacher’s Reported Role as a Math Leader among Peers</th>
<th>RQ4 Math Instruct’l Authorization (MIAA) Completion Status (1=yes, 0=no)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>ΔR²</td>
<td>β</td>
<td>ΔR²</td>
</tr>
<tr>
<td>Dialogue</td>
<td>-.207</td>
<td>.042</td>
<td>.026</td>
<td>.001</td>
</tr>
<tr>
<td>Decision-Making</td>
<td>-.294*</td>
<td>.086</td>
<td>-.189</td>
<td>.034</td>
</tr>
<tr>
<td>Taking Action</td>
<td>.076</td>
<td>.006</td>
<td>.076</td>
<td>.006</td>
</tr>
<tr>
<td>Evaluation</td>
<td>-.303*</td>
<td>.091</td>
<td>.100</td>
<td>.010</td>
</tr>
</tbody>
</table>

Note. * p < .10

Qualitative Data

Following the close of the Teacher Collaboration survey period, ten Abacus participants representing a variety of teaching assignments and levels of program success were recruited for follow up interviews. Program success was defined by a post-project observation score using the Math Talk Learning Community rubric (NCTM, 2004). Seven participants agreed to meet in person with the researcher during a two-week period following completion of TCAS data collection. The researcher met with interview participants at their individual school sites and a pre-planned interview protocol (See Appendix E) was used as the foundation for each session. Teacher interviews were audio-recorded.

Table 21, below, provides background information for the seven interview participants. As previously noted, the researcher purposefully recruited Abacus participants teaching a variety
of grade levels who were representative of the different rural school settings (public, public charter, and private), and achieving different levels of success, as defined by their post-project observation scores. To ensure confidentiality for the subset of interviewees, identifying information is limited to the teacher’s grade level. In addition, pseudonyms have been assigned to interview participants as well as other Abacus teachers whose names were mentioned during the audio-recorded meetings.

Table 21
*Interview Participants*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Grade(s) Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elizabeth</td>
<td>Kindergarten</td>
</tr>
<tr>
<td>Claudia</td>
<td>Kindergarten</td>
</tr>
<tr>
<td>Maggie</td>
<td>Second</td>
</tr>
<tr>
<td>Kevin</td>
<td>Sixth</td>
</tr>
<tr>
<td>Maya</td>
<td>Fourth</td>
</tr>
<tr>
<td>Anika</td>
<td>Fourth/Fifth</td>
</tr>
<tr>
<td>Sam</td>
<td>Third</td>
</tr>
</tbody>
</table>

Before transcribing interviews, the researcher listened to audio-recorded participant responses twice, taking notes for an initial analysis (Maxwell, 2013). Next, transcribed interviews were analyzed to identify themes connected with teachers’ perceptions about collaboration during the Abacus project. During the analysis phase, the researcher identified phrases and created coding categories based on terms and descriptions provided by the interview participants (Creswell, 2012; Glaser & Strauss, 1967; Maxwell, 2013).
As described in Chapter Three, the researcher served as a facilitator of mathematics workshops connected with Abacus, and as such, established a professional working relationship with program participants, creating potential bias. Creswell (2012) states researchers must, “bracket out, as much as possible, their own experiences” (p. 81). While interpreting interview data, the researcher practiced regular reflection to examine positionality as a form of critical reflexivity (Creswell, 2012; McMillian & Schumacher, 2010). In addition, the researcher selected a colleague not connected with Abacus or this research to serve as a peer debriefer. The peer debriefer reviewed interview transcriptions and the researcher’s analysis to identify threats to objectivity (McMillan & Schumacher, 2010).

**Research Question Five – Scope of Collaboration**

What are rural teachers’ perceptions regarding the possible effects of collaboration during a two-year professional learning program on their practice as mathematics educators?

a) In what ways, if any, do program participants collaborate about mathematics?

b) In what ways, if any, have participants implemented classroom practices derived from collaborative discussions with colleagues from the professional learning program?

**Results Addressing Research Question Five**

Abacus participants provided many examples of their experiences working together during the two-year professional learning program. During their interviews, participants described their collaborative tasks and what connected them with colleagues. They also described how it felt to be immersed in math activities with people familiar and unfamiliar to them. Table 22, below, identifies the nature and frequency of predominant themes that surfaced during interview analysis. Data presented in the table reflect the number of times a participant made a statement associated with one of the predominant themes.
Five participants described doubts about their mathematics knowledge, and how their abilities might be viewed by other program participants. Frequently during their interviews, all seven participants enthusiastically expressed feelings of joy attributed to math tasks, their work, and the work of others in the Abacus program. The most frequent theme, connection to colleagues and math tasks, was evident among all interviewees. The final theme, purpose, surfaced in five of seven interviews. Comments attributed to purpose were connected with participants’ desire and action-taking to implement what was learned during the Abacus program.

Table 22

<table>
<thead>
<tr>
<th>Participant</th>
<th>Self-Doubt</th>
<th>Joy</th>
<th>Connection</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elizabeth</td>
<td>11</td>
<td>8</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>Claudia</td>
<td>0</td>
<td>4</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Maggie</td>
<td>9</td>
<td>15</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Kevin</td>
<td>5</td>
<td>9</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Maya</td>
<td>5</td>
<td>19</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Anika</td>
<td>10</td>
<td>14</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>Sam</td>
<td>0</td>
<td>17</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>40</td>
<td>86</td>
<td>126</td>
<td>21</td>
</tr>
</tbody>
</table>

Note. Themes were identified following the researcher’s analysis of the subjects’ transcribed interviews.
Self-Doubt

Five of seven interviewees described concerns about their mathematics knowledge and a fear of being exposed or judged by other participants for their lack of ability. Participants identified as Elizabeth, Maggie, Maya, and Anika revealed during their interviews that they were nervous about the idea of collaborating with other teachers when the Abacus program began in 2016. Maggie used the following words to describe her experience on the first day of the program:

The first day, everyone seemed kind of cliquish. I wanted to arrive early to save a seat for Casey (pseudonym), my coworker at school. We did not want to sit near sixth grade teachers because they know a lot about math and we did not want to slow them down. Elizabeth, a kindergarten teacher, explained that she studied a colleague’s math textbook before the first Abacus meeting, out of concern she’d be called on to solve a problem requiring knowledge beyond the kindergarten level. And Anika, a teacher of fourth and fifth grade students, remembers wanting to participate in Abacus because she “was never a math person,” meaning, “not good at math.”

Interview participants provided further examples of self-doubt as they described their collaboration with colleagues beyond the first day of Abacus. Describing a collaborative math task during the program’s first summer institute, Elizabeth stated,

Robert (pseudonym) was helpful, especially when it was beyond the kindergarten math brain. He was like, ‘Oh I can explain that to you.’ He never made you feel as though you didn’t have a clue, he would jump right in to help.

Kevin, who teaches sixth grade, explained his “anxiety” when drawing models to explain multiplication and division of fractions:

I knew everything was different in Common Core but I never got trained in that. I kind of covered up my paper because I didn’t want them to see, but I looked at my neighbor’s paper, just like my students do, to see if I had the right answer.

Maggie recalled an incident during the second summer institute where she felt uncomfortable being paired with another participant because she remembered the other participant rolling her eyes when Maggie asked a question in an earlier professional learning session. She described
that upon “having” to work with the participant, she’d wanted to cry. Maggie noted, however, “I was really surprised how nice she was and we had fun that day. We are still friends and share ideas about our classrooms.”

Elizabeth, Maggie, Maya, and Kevin revealed during the interview their changing sense of efficacy as math teachers as they continued to participate in the professional learning sessions offered through Abacus. Maya noted, “The more I learned, the more I realized I could have been a better math teacher. It made me sad. But I was also happy, I was learning new ways to teach I never knew before.”

**Joyful Learning**

In varying degrees, all interview participants expressed joyful experiences, learning and doing math together during Abacus. Professional learning sessions included time for exploration, practice, conversation, and reflection, centered around math tasks and tools.

In addressing math tasks in general, the participant identified as Claudia, a kindergarten teacher, remarked, “I loved the math problems! It was so much fun to work on them with everyone!” Also, when recalling her collaboration during an after-school Abacus session, Claudia remarked, “Hearing things presented in a new way - figuring out how to solve things in a new way, I mean it’s like exercising your brain. I just love it!” Sam, who lived an hour’s drive from the summer institute location stated, “It didn’t matter, the time. I got up, ready to get in the car because I knew we were going to do cool stuff.” And Anika, who’d already described herself as a non-math person offered, “My head was full of ideas. Exciting ideas I could not wait to share with my kids.”

Several participants experienced bliss when working with math tools. Elizabeth recalled a series of tasks involving the use of a number balance. While describing her group’s work with
the tool, she smiled and excitedly explained, “The number balances, they were awesome! We kept coming up with so many ideas for how to use them!” Sam also talked about “having fun” with the number balance explaining, “We lost track of time that day. It was lunch time. Time to go. But we wanted to keep trying out our ideas.” And regarding another math tool, attribute blocks, Maggie shared, “Wow, so simple but so many ways to talk about them.”

All interviewees talked about math tasks as an experience that brought them closer to their colleagues, and all named several other participants they’d met during a math task, decided they liked the colleague, and continued to work with them for the duration of the program. Maya described a math task involving the building of fraction kits, and a game she’d played with a partner.

It was getting kind of competitive and I didn’t want to hurt her feelings, but then she beat me at Fringo and we laughed. I said, wait, no way! I was supposed to win! After that day, we had this kind of fun competitive spirit. We laughed a lot.

Kevin laughed during the interview, remembering his participation in a probability game modeled after the show Lets Make a Deal, noting, “Oh my God, the clapping and hollering and cheering. So funny. I picked the goat. We still talk about that game!” The goat was an inside joke to Abacus participants. It first appeared in a challenging math scenario during an early professional learning meeting. Because participants found humor in the math problem, project facilitators continued to incorporate goat stories and goat pictures in later sessions.

Two participants, Claudia and Sam, talked about looking forward to arriving early during the summer institutes to work with others who’d arrived early, solving a series of math problems posted on the classroom’s whiteboard. The problems would be used to inspire thinking, the sharing of ideas about multiple ways to approach a solution, and to begin math conversations at the start of each day. Claudia and Sam viewed the white board problem solvers as a “club” of
sorts, a reason to connect with other program participants; often those you might not be a part of your table group.

**Connection**

Connection, the most prevalent theme to surface during participant interviews, was expressed in many contexts among the interview participants. Elizabeth, Maggie, Kevin, Maya, and Sam talked about their connection to other participants, known and unknown prior to Abacus, because of their “ruralness.” Elizabeth commented:

> We are a different breed of educators and breed of students, like-minded in rural areas. And, we may not have access to all of the things that larger districts have access to and this was an important part to us.

Maggie noted:

> I wanted to meet other teachers in my grade level. I am the only one teaching second grade at my school, in my whole town. Wow, to be able to meet Sandy (pseudonym) who not only teaches in another town but at a charter school. We have kids the same age so we really bonded and now we do soccer together. Besides math, which is the most important (laugh).

And, Kevin offered:

> We work hard, but we liked having fun together. We never seem to have time but this put us all together. And I got to meet teachers a hundred miles away who are in the same kind of school.

Abacus participants also found connection in what they described as their love of math and enjoying the experience of solving “really tough” problems together during the program. Despite several participants expressing self-doubt at different times during Abacus, all interviewees described a sense of connectedness when working hard to successfully complete a math task they’d worked on together. Maggie noted, “We were never really independent, we didn’t feel like we could not ask a question. We were learning together.” And, Elizabeth summed up her shared experience, saying, “We were all just lying naked. We broke bread
together.” For Elizabeth in particular, who’d described several moments of self-doubt with her “kindergarten brain,” she grew to feel comfortable with being vulnerable in her learning experience with the group.

**Purpose**

During their interviews, most participants provided examples of collaborating with colleagues to implement what was learned during Abacus. Anika, Elizabeth, and Maggie described how they were now teaching project-based math units in their classrooms. Elizabeth explained that since the conclusion of Abacus, she has taught other teachers at her school site about a project based approach to math and she has helped them with ideas for math units at their grade levels.

Claudia explained that she now sees math in everything and has shared this with her kindergarten students:

> Today we got these new alphabet stepping stones, two different sizes. We put them out in order. The kids helped me. One of my kids said, hey, this is a pattern! High low high low. Gray brown tan gray brown tan. They see patterns. I don’t need to ask them anymore about patterns. I taught them to notice and now they tell me. That helps not only with math but it helps with reading.

Elizabeth, Maggie, and Maya shared that they have taken an increased role in mathematics leadership at their school sites, and within their districts. They are now facilitating professional learning workshops for other teachers in their communities and report having used some of the math tasks, strategies, and manipulatives they learned while in Abacus. Maya stated, “At first, it didn’t seem like my principal cared. We are too busy at my school. Then the math scores came out and he was like, what are we going to do? Allison (pseudonym) and I said, we can share our Abacus stuff!”
Summary for Research Question Five

As outlined above, program participants reported several examples of their collaborative work during the Abacus project (RQ 5a). When thinking about collaborative experiences, several participants described concerns about how they might be perceived by their peers in terms of math ability. However, through frequent interactions offering joyful experiences with math, participants built working relationships with colleagues from other schools and looked forward to their professional learning sessions.

Having a shared identity as teachers serving rural schools and the shared experience with math games and math tasks, Abacus experiences supported development of a collaborative environment during and after the conclusion of the Abacus program.

When describing implementation of practices derived from program collaboration (RQ 5b), participants provided examples of project-based learning practices for the teaching of math. In addition, several participants have shared strategies, tools, and tasks experienced during Abacus with other colleagues. Three interviewees described their current role in leading professional learning workshops for other teachers, incorporating their work from Abacus. And, six of the seven interviewees asked if something like Abacus would be offered again in the future, explaining they would like to be a part of a project like it again to continue refreshing their math teaching practice.
CHAPTER 5: DISCUSSION

This chapter presents a summary of a study of 38 rural teachers who participated in Abacus, a two-year professional learning program designed to create a collaborative community of practice focused on the building of mathematics content knowledge, pedagogy, and leadership. Important conclusions drawn from the data presented in Chapter Four are presented here, as well as a discussion of the implications and recommendations for further research.

This mixed-method dissertation study explored the extent to which teachers’ perceptions about their opportunities to collaborate with peers during Abacus were related to their professional growth as mathematics educators. Four research questions addressed Abacus participants’ perceptions about collaboration as related to:

1. *Self-reported instructional practice.* After controlling for teachers’ initial self-reported rating of the quality of their daily mathematics instructional practice, to what extent can variation in their self-reported rating of the quality of their daily mathematics instructional practice, reported at the end of the two-year professional learning program, be accounted for by their perceptions of the quality of program collaboration as indicated by four key facets of collaboration.

2. *Observed practice in facilitating mathematics discourse.* After controlling for initial rubric scores connected with the observation of teachers’ role in facilitating student-led mathematics discourse, to what extent can variation in rubric scores connected with the observation of teachers’ role in facilitating student-led mathematics discourse, reported at the end of the two-year professional learning program, be accounted for by teachers’ perceptions of the quality of program collaboration as indicated by four key facets of collaboration.

3. *Role as a mathematics leader.* After controlling for the initial number of colleagues who viewed the teacher as a school-site mathematics leader, to what extent can variation in number of colleagues who viewed the teacher as a school-site mathematics leader, reported at the end of the two-year professional learning program, be accounted for by their perceptions of the quality of program collaboration as indicated by four key facets of collaboration.

4. *Mathematics Instructional Added Authorization Completion.* Is there a difference in the average perceptions of quality of program collaboration, as indicated by four key facets of collaboration, between program participants who did and did not earn their Mathematics Instructional Added Authorization?
A fifth research question examined the scope of collaboration among program participants, with interview data collected from seven Abacus participants following completion of the professional learning program.

5. **Scope of Collaboration.** During their interviews, participants described how they collaborated with other Abacus teachers about mathematics, and how the collaboration impacted their classroom practice.

**Summary of Findings**

A series of four hierarchical linear regression analyses were conducted to evaluate data for the first three research questions addressing self-reported instructional practice, observed practice in facilitating mathematics discourse, and role as a mathematics leader.

**RQ1: Self-Reported Instructional Practice**

Hierarchical regression analyses were completed for teacher self-reported rubric scores collected through the Silicon Valley Math Initiative (SVMI) Mathematics Teaching Rubric (controlling for initial self-reported perceptions) and participant responses to the Teacher Collaboration Assessment Rubric (TCAR) survey. The collaboration variable, action-taking, had a positive regression coefficient, suggesting a positive association with teachers’ self-reported mathematics instructional practice. Regression coefficients for the remaining collaboration variables, dialogue, decision-making, and evaluation, indicated a negative association with teachers’ self-reported mathematics instructional practice, which can be explained by response-shift bias (Cartwright & Atwood, 2014). During the course of multiple professional learning sessions, Abacus participants continued to learn and practice new teaching strategies aligned with K-12 mathematics content. Ongoing exposure to newly learned content and pedagogy likely caused participants to view their practice with a more critical eye (Cartwright & Atwood, 2014).
Initial analysis of the data revealed statistically significant relationship between collaborative decision-making \( (p = .056) \) and collaborative evaluation \( (p = .049) \) as predictors for participants’ self-reported instructional practice. However, results were no longer significant following application of a Bonferroni adjustment to control for the Type 1 error rate across related sets of analyses, where the alpha was adjusted from .10 to .025. Still, given the small sample size \( (n = 38) \) and the exploratory nature of this research, the possible predictive nature of collaborative decision making and evaluation are worth noting.

**RQ2: Observed Practice in Facilitating Mathematics Discourse**

Hierarchical regression analyses were completed for participants’ role as facilitators of student-led mathematics discourse collected through classroom observations and using the NCTM (2004) Math Talk Learning Community Rubric (controlling for initial observed practice rubric scores) and participant responses to the TCAR survey. While regression coefficients for three of four collaboration variables; dialogue, action-taking, and evaluation, were positive and suggested a positive association with observed practice in facilitating discourse. A positive regression coefficient for the variable collaborative decision-making suggested a negative association between this factor and teachers’ observed practice in facilitating mathematics discourse. None of the four key collaboration factors addressed in the TCAR were statistically significant predictors of Abacus participants’ observed practice in facilitating student-led mathematics discourse.

**RQ3: Role as a Mathematics Leader**

Hierarchical regression analyses were completed to study variation in the number of colleagues who viewed the teacher as a school-site mathematics leader (controlling for the initial number reported at the beginning of Abacus) and participant responses to the TCAR survey.
Regression coefficients for all four collaboration variables; dialogue, teamwork in decision making, action-taking, and evaluation, were positive and suggested a positive association with Abacus teachers’ roles as school-site mathematics leaders. Following initial data analysis, one collaboration factor, evaluation \( (p = .049) \) was a significant predictor of participant site. After Bonferroni adjustment to control for the Type 1 error rate across related sets of analyses, where the alpha was adjusted from .10 to .025, collaborative evaluation was no longer a significant factor. However, given the sample size \( (n = 38) \) and the exploratory nature of this research, the possible predictive nature of collaborative evaluation for being recognized as a mathematics leader is worth noting.

The remaining three key collaboration factors; dialogue, decision-making, and action-taking, were not significant predictors of participants’ roles as school-site mathematics leaders.

**RQ4: Mathematics Instructional Added Authorization Completion**

Analyses of independent-samples t-test addressing possible variation in participant responses to the TCAR survey among MIAA completers and non-completers in the Abacus program suggested no significant differences in their perceptions about collaboration in the areas of dialogue, teamwork in decision making, action-taking, and evaluation.

**Limitations**

As outlined in Chapter Three, there were concerns regarding the collection and analysis of quantitative data for a relatively small sample of teachers \( (n=38) \). Given the small sample size, this dissertation study was designed as an exploration to better understand perceptions among a group of teachers from rural schools who participated in the shared experience of professional learning in the two-year Abacus program. Using caution, and with consideration for samples of teachers whose characteristics are similar to those participating in Abacus, we note
the initial significant connection between two of four collaboration components and the variables studied for this research (collaborative decision-making as a predictor of participants’ self-evaluation of their teaching practice, and collaborative evaluation as a predictor of participants’ self-reported teaching practice and their role as school site mathematics leaders), prior to the Bonferroni adjustment. Generalizing any results from this research, significant and nonsignificant, is most appropriate when considering groups of teachers with similar characteristics who experience a professional learning program similar to Abacus. This dissertation study was connected with a specially designed professional learning program serving a specific group of teachers from rural communities which are rarely the subject of scholarly research.

**RQ5: Scope of Collaboration**

While quantitative data analyses, post-Bonferroni adjustment, did not reveal a significant predictive relationship between collaboration and several measures of teachers’ professional growth during Abacus, follow up interviews with seven teachers provided insight regarding their experiences as program participants and their perceptions about the nature of collaboration with other teachers. Interviews of a subset of seven participants is more than adequate to study a phenomenology of the specific group’s shared experience as collaborators in Abacus (Creswell, 2012).

Those who were interviewed commented most often about the connections they were able to make with other Abacus participants, sharing common experiences through their work in rural schools. As previously noted, educators working in rural settings often feel isolated in terms of their geographic location and proximity to peers. In addition, rural schools struggle with access to resources – time, funding, professional learning, etc. Interviewees described the
building of relationships and making connections with colleagues during Abacus, not only in terms of their teaching in a rural setting, but through the shared experience of collaborating on math tasks.

Five of seven interviewees described feelings of self-doubt in their mathematics expertise, and the building of confidence through the collaborative solving of math problems, talking about the solving of math tasks, and gaining perspective on the teaching of math across many grade levels. Abacus participants created collaborative partnerships with other teachers by honoring different ways of thinking and varied grade level expertise. Kindergarten teachers gained insight regarding the upward trajectory of conceptual understanding, and sixth grade teachers developed a stronger understanding of teaching foundational math skills to young learners.

Interviewees also attributed their collaboration around math tasks to a sense of wonder and joyful learning experiences in Abacus. Wonder and joyfulness, as well as the connections with other rural teachers, were a force that kept participants engaged throughout the two-year program. Interviewees reported a sense of excitement about weekend and summer institutes. They looked forward to collaborative conversations and work with their Abacus colleagues, setting the workshops as a priority in their schedules. The two-year program saw no attrition with all year one program completers continuing through the last Abacus meeting. All interviewees reported that they have continued to collaborate with program participants, months after the final meeting in the fall of 2017.

**Implications**

By nature, rural settings can be difficult to study due to their unique location and contexts (Schulte, 2016). This may be a factor in the dearth of scholarly research addressing rural
education. Although they are often overlooked in the field of educational research, 57% of school districts and 32% of schools in the United States serve rural communities (National Center for Education Statistics, 2011). While this dissertation study focused on a small number of teachers, gaining insight to their shared experience as educators allows the greater community to better understand their rural context, and to examine similarities and differences to other school settings.

Data gathered during this research reinforced prior research indicating that effective and professional learning must be relevant to its participants. In this case, the Abacus program was designed in response to the implementation of the California Common Core State Standards and provided its rural teacher participants with opportunities to experience the standards as learners and educators. Teachers collaborated to solve problems and practiced using math manipulatives in what they described as joyful learning experiences.

Professional development should also provide ongoing support, including the scheduling of meetings that are respectful of teachers’ schedules and commitments. Abacus meetings avoided parent conference weeks, report card due dates, and standardized testing schedules. Rural teachers participating in the program reported looking forward to program meetings as a way to experience joyful learning and share how they had implemented newly learned strategies within their classrooms.

Further, data gathered during this study revealed the importance of relationships within professional learning programs. Participants need opportunities to make connections with one another through the sharing of common identities (in this case, as rural teachers) and common learning experiences. In addition, positive relationships between facilitators and participants create a positive learning environment and desire for teachers to remain committed to attending
workshops and meetings embedded in the program. Follow up interviews with Abacus participants reinforced the role of relationships and community as a factor in teachers’ successful completion of the two-year program. Of the 38 teachers who joined Abacus in the spring of 2016, all remained in the program through its completion in late 2017. Communities of Practice, the theoretical framework for this dissertation, aligns with teachers’ building of a shared culture (Wenger, 1998) through their participation in Abacus workshops.

Participants, through their interview responses, described initial concerns about the way their math abilities would be viewed by others in the program. Collaborative partnerships were established when teachers realized their math knowledge and expertise would be validated by their colleagues, and through the joyful practice of working together on math tasks. Through collective learning and knowledge-building (Thebald & Siskar, 2014; Wenger, 1998) Abacus participants strengthened their sense of belonging and a shared culture. The Abacus program central to this research created an environment allowing development of a new community of rural school teachers, many of whom have continued to collaborate across district and county lines, months after the program was completed.

**Further Research**

Roberts (2014) discusses the importance of thinking of rural contexts as valuable, giving voice to communities that have “remained outside of knowledge production” (p. 141). Given that rural schools populate much of the United States, we need to continue to find opportunities to better understand and honor the voices of educators and students in rural communities.

The sample studied for this dissertation included 38 teachers from 14 schools in four Northern California counties. While acknowledging the uniqueness of individual rural communities and schools, they can share common experiences with limited access to resources
such as professional learning (Arnold, Newman, Gaddy, & Dean, 2005; Barrett, et. al, 2015; Stewart & Matthews, 2015). Prior to the application of a Bonferroni adjustment, this study revealed possible significant connections between collaborative decision making ($p = .056$) and evaluation ($p = .049$) as predictors for rural teachers’ self-reported math practice. There was also a possible connection between collaborative evaluation ($p = .049$) and rural teachers’ math leadership roles. Future studies of rural teachers experiencing professional learning within communities of practice can shed further light on possible connections between collaboration and their math practice.

Further research could include the use of case studies and action research to study specific effects of professional learning in local contexts. Knowledge gained from further research can help inform the development of professional learning curriculum and programs to meet the needs of teachers in rural communities.
REFERENCES


Zito, M.F. (2011). Is working together worth it: Examining the relationship between the quality of teacher collaboration, instruction, and student achievement. ScholarWorks @UMass Amherst, 1-189
APPENDIX A: INFORMED CONSENT FORMS

Consent Form - Survey

The following information is provided so that you can decide whether you wish to participate in my dissertation study. As you know, the PRIME project which you participated in, and its associated evaluation, concluded in 2017. This study is not a requirement for participating in PRIME. My research study is an extension of PRIME and will make use of the de-identified database, but your participation at this point is voluntary. Also, if you do consent to participate, you are free to withdraw at any time.

The purpose of my research study is to better understand teachers’ perceptions regarding the work they completed for the PRIME project and how their professional identity as mathematics educators may have changed. There are no wrong or right answers; perspectives are likely to be unique for each teacher.

As part of my research, I plan to use an online survey to gather information from PRIME teachers during October, 2018 through November, 2018. If you wish to participate, the survey should take no more than 10 – 15 minutes to complete. The survey involves the rating your level of agreement or disagreement with a series statements regarding teacher collaboration. In addition, there are 5 open-ended questions providing you with the opportunity to share additional thoughts regarding your experience as a PRIME project participant. You are free to discontinue the survey at any time and can do so by skipping to the submit button at the end, or by closing your web browser. You are not asked to identify yourself by name; however, you are asked to provide the 3 or 4 digit project ID number you used for PRIME.

Professor Rachelle Kisst Hackett, my dissertation chair, has emailed you a copy of the unique identification number assigned to you during the PRIME project (for which she served as the evaluator). We would like for you to continue to use this identification number in lieu of your name. To ensure your data are kept confidential, your survey responses will be routed to Dr. Hackett, who will merge the information with previously collected PRIME data. I will have access to the merged files for data analysis. The merged files will not contain any information regarding teacher or school site names, nor will any math test scores (from the PRIME summer institutes) be included.

Electronic survey data, collected via Google Forms, will be password protected to further ensure the confidentiality of your responses. During the merging and analysis of survey data, information will be downloaded into a spreadsheet which will be stored in a password-protected electronic folder.

Only Dr. Hackett has access to the master key linking PRIME teacher names and identification numbers. It is kept by her in a password-protected folder separate from the now archived data she used in the original evaluation of PRIME in 2016 and 2017. I do not, and will not, have access to that key. Thus, your data is confidential to her, but it is anonymous to me.
The information about the experiences and practices in participating in a professional learning program designed for rural school teachers that you and other PRIME participants provide should be beneficial to those working to improve educational practice for both teachers and students.

Teachers participating in the survey will have the option of entering a drawing to win one of five $35.00 Amazon gift cards. After clicking the submit button at the end of the survey, you will be provided with a link to a separate online survey to enter the drawing. You will not be required to enter the drawing, but if you choose to do so, your information will be stored separate from any survey data to protect the confidentiality of your response. Anyone who begins, but discontinues the survey, is still eligible to win a gift card by clicking the survey’s submit button to access a link to enter the drawing.

There are no foreseeable risks and/or discomforts associated with this study, beyond the minimal risks one encounters in daily life. Procedures noted above are put in place to minimize the loss of confidentiality risk.

If at any time you have any questions about the research, please contact the researcher, Katie Burns, by emailing kburns@sjcoe.net or calling (209) 518-3948. You are also welcome to contact my dissertation advisor (who served as the PRIME Program Evaluator) Professor Rachelle Kisst Hackett by emailing rhackett@pacific.edu or calling (209) 946-2678.

If you have any questions about your rights as a participant in a research project, or in the event of a research related injury, please call the Office of Research & Sponsored Programs, University of the Pacific (209) 946-7716.

Your consent is required to confirm your voluntary participation in this research study. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time and no penalty or loss of benefits, to which you are otherwise entitled, will occur.

Clicking the “Continue” box (from the first page of the on-line survey) that you have read and understand the information provided above, that your participation is completely voluntary, that you may withdraw your consent at any time and discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled, that you will receive a copy of this form, and that you are not waiving any legal claims, rights, or remedies. A copy of this form was attached to the email you were sent when you were first invited to participate and provided with the link to the survey; you are also welcome to take a screenshot of the Informed Consent Form when beginning the on-line survey.

Thank you, in advance, for taking the time to read this and consider if you would like to participate in my dissertation study.
Regards,
Katherine Burns,
Doctoral Student
University of the Pacific
kburns@sjcoe.net

By clicking “Continue” below, I have read the above information and consent to participate in this research study.
Consent Form – Interview

The following information is provided so that you can decide whether you wish to participate in my dissertation study. As you know, the PRIME project which you participated in, and its associated evaluation, concluded in 2017. This study is not a requirement for participating in PRIME. My research study is an extension of PRIME and will make use of the de-identified database, but your participation at this point is voluntary. Also, if you do consent to participate, you are free to withdraw at any time.

The purpose of my research study is to better understand teachers’ perceptions regarding the work they completed for the PRIME grant and how their professional identity as mathematics educators may have changed. There are no wrong or right answers; perspectives are likely to be unique for each teacher.

As part of my research, I plan to individually interview several PRIME teachers between October, 2018 and December, 2018. I would meet with you at your school site or another location convenient to you for an interview lasting approximately one hour that, with your permission, would be audio-recorded.

There are no foreseeable risks and/or discomforts associated with this study, beyond the minimal risks one encounters in daily life. The interviews will have a conversational tone and you can choose to not answer any questions, should you ever feel uncomfortable. In-person interviews will be audio-recorded and transcribed during which participant and school identification information will be replaced with a set of codes to ensure confidentiality. An electronic copy of the audio recording and transcription will be stored in a password-protected folder, and any printed copies of transcribed interviews will be stored in a locked cabinet. The master key used for interview data, linking names to participant and school ID codes will be kept in a separate locked cabinet. Participant responses will be reported using pseudonyms to minimize the loss of confidentiality risk.

The information about the experiences and practices in participating in a professional learning program designed for rural school teachers that you and other PRIME participants provide should be beneficial to those working to improve educational practice for both teachers and students. Teachers who meet with me will be eligible to win one of three $35 Amazon gift cards. Anyone who begins, but discontinues the interview, will still be entered into the random drawing.

If at any time you have any questions about the research, please contact the researcher, Katie Burns, by emailing kburns@sjcoe.net or calling (209) 518-3948. You are also welcome to contact my dissertation advisor (who served as the PRIME Program Evaluator) Professor Rachelle Kissel Hackett by emailing rrhackett@pacific.edu or calling (209) 946-2678.
If you have any questions about your rights as a participant in a research project, or in the event of a research related injury, please call the Office of Research & Sponsored Programs, University of the Pacific (209) 946-7716.

Your written consent is required to confirm your voluntary participation in this research study. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time and no penalty or loss of benefits, to which you are otherwise entitled, will occur.

Your signature below indicates that you have read and understand the information provided above, that your participation is completely voluntary, that you may withdraw your consent at any time and discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled, that you will receive a copy of this form, and that you are not waiving any legal claims, rights, or remedies.

Signature ___________________________ Date __________

Printed Name ___________________________
Abacus Program Collaboration Survey

This questionnaire is designed to assess your perceptions of the Abacus program and your role in our Summer Institute, Saturday sessions, and after-school meetings. Please answer the questions truthfully and to the best of your ability. You should be able to complete this survey in about 10 - 15 minutes.

1. What is your Abacus ID number?

2. I feel like the Abacus community had all of the people and other resources it needed to achieve the goal of improving student learning.
Mark only one oval per row.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Agree

Choose one.

3. During Abacus, I had regular face-to-face meetings with colleagues in the Abacus program.
Mark only one oval per row.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Agree

Choose one.

4. It was the norm for everyone involved to attend our face-to-face meetings in the Abacus program.
Mark only one oval per row.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Agree

Choose one.

5. Meetings with colleagues about the Abacus program tended to have balanced participation from all.
Mark only one oval per row.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Agree

Choose one.

6. When I met with colleagues about Abacus, our discussions and activities were generally structured (e.g., we had an agenda).
Mark only one oval per row.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Agree

Choose one.
7. **Discussions about the Abacus program focused on using evidence to analyze practice and the effects of teacher practice on student learning.**
Mark only one oval per row.

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8. **When talking about Abacus with colleagues, I used the dialogue as a way to examine my personal beliefs and assumptions.**
Mark only one oval per row.

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9. **Pedagogical and philosophical disagreements with colleagues occurred during Abacus, but we were able to work through them.**
Mark only one oval per row.

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Choose one.

10. **When discussing Abacus with colleagues, I consistently focused on the project’s goal to improve student learning.**
Mark only one oval per row.

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Choose one.

11. **When working with colleagues on Abacus tasks, we would make ongoing decisions about the pedagogical practices we would employ.**
Mark only one oval per row.

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Choose one.

12. **When making group decisions about Abacus activities, the processes for making the decisions were clear and consistently followed.**
Mark only one oval per row.

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13. **Decisions about Abacus activities were fully informed by group dialogue.**
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Choose one.
14. The decisions that I made about Abacus activities directly related to improve student learning.
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15. When making group decisions about Abacus activities, the group was clear about the scope of its decision making.
Mark only one oval per row.

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16. Abacus leadership (Dr. Y and Ms. Z) were visible and accessible.
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17. My individual actions related to Abacus supported group goals and decisions.
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18. I view what I did in Abacus as pedagogically and professionally complex and challenging.
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19. My work in Abacus was intended to directly improve student learning.
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20. When working with colleagues on Abacus activities, everyone participated equally.
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21. 20. I systematically collected and preserved evidence about what I did during Abacus. Mark only one oval per row.

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22. 21. I have systematically collected evidence about impacts of Abacus on student learning. Mark only one oval per row.

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23. 22. My colleagues and I used evidence and not just anecdotal information to evaluate practice or make decisions. Mark only one oval per row.

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24. 23. During Abacus my colleagues and I regularly accomplished tasks and set new goals. Mark only one oval per row.

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25. 24. During Abacus, my colleagues and I regularly celebrated and publicly acknowledged our accomplishments. Mark only one oval per row.

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26. 25. I feel that I was a contributing member of the Abacus partnership. Mark only one oval per row.

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27. 26. I believe I had the administrative support I needed to participate in the Abacus program. Mark only one oval per row.

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28. Some things regularly interfered with my ability to fully participate in Abacus.  
Mark only one oval per row.

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29. I feel confident in my ability to have contributed to the Abacus program.  
Mark only one oval per row.

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30. I am confident in my ability to have implemented mathematics practices learned during Abacus.  
Mark only one oval per row.

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31. Overall, I have a positive perception of partnerships created during Abacus.  
Mark only one oval per row.

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32. What factors of Abacus do you think have supported your efforts as a math teacher?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

33. What factors of Abacus do you think have impeded your efforts?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
34. In what ways did the administration of your school/district support your participation in Abacus?

------------------------------------------------------

35. In what ways do you feel you have personally or professionally benefitted from participating in Abacus?

------------------------------------------------------

36. What suggestions do you have for improving programs such as Abacus?

------------------------------------------------------
# APPENDIX C: MATHEMATICS TEACHING RUBRIC

## Evaluation Question #2b (first measure): Teacher self-reports using “The Mathematics Teaching Rubric” by Silicon Valley Mathematics Initiative

Components being judged: a) worthwhile tasks; b) the learning environment; c) teacher's role in discourse; d) student's role in discourse; e) tools for enhancing discourse; and f) teaching & learning analysis.

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Worthwhile Tasks</strong></td>
<td></td>
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</tbody>
</table>

The teacher engages the students in worthwhile tasks. The tasks are part of a coherent curriculum that develops students' understanding and facility with mathematics. The mathematics of the tasks is clear and aligned with core standards and developed to make sense of the world. Most of the tasks engage students’ thinking, conceptual development, and problem solving as well as skills. The tasks involve a wide range of contexts (graphs, data, problems, models, equations, manipulatives, technology, etc.). The tasks require mathematical and tasks that build on and extend from the students’ understanding. Most of the tasks foster students’ ability to solve problems, reason and communicate. The tasks range across visual thinking and representations. The tasks may grow out of a student’s conjecture or question. Often the tasks may be approached in more than one interesting and legitimate way. Most of the tasks are in length of time required to develop solutions. |

| **Successful Teaching** | 

The teacher engages the students in worthwhile tasks. The tasks are usually balanced between engaging students’ thinking, conceptual development, and problem solving as well as skills. Some of the tasks involve a range of contexts (graphs, data, problems, models, equations, manipulatives, technology, etc.). The tasks require mathematical and tasks that build on and extend from the students’ understanding. Most of the tasks foster students’ ability to solve problems, reason and communicate. The tasks range across visual thinking and representations. The tasks may grow out of a student’s conjecture or question. Some of the tasks may be approached in more than one interesting and legitimate way. Some of the tasks are in length of time required to develop solutions. |

| **Limited Teaching** | 

Occasionally the teacher engages the students in worthwhile tasks. The tasks are usually part of a coherent curriculum. The mathematics of the tasks focuses on skill acquisition and developing procedural knowledge. Most of the tasks engage students’ thinking, conceptual development, and problem solving as well as skills. The tasks involve a range of contexts. The tasks may grow out of a student’s conjecture or question. Some of the tasks may be approached in more than one interesting and legitimate way. Some of the tasks are in length of time required to develop solutions. |

## The Learning Environment

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4 - Expository Teaching</strong></td>
<td></td>
</tr>
</tbody>
</table>

The teacher creates a classroom environment where students actively construct their own understanding of mathematics and learn to use mathematics to make sense of the world. The teacher fosters the development of each student’s mathematical power and supports the class as a community of learners. The teacher provides students with the time necessary to explore mathematics and graph with significant ideas and problems. The physical space and materials are arranged and allocated so that students can work independently or collaboratively to make sense of mathematics. Students take intellectual risks by raising questions, sharing ideas, and formulating conjectures. The students display a sense of mathematical competence by validating and supporting ideas with mathematical arguments. |

| **3 - Successful Teaching** | 

The teacher allows students to actively construct their own understanding of mathematics and learn to use mathematics to make sense of the world. The teacher fosters the development of each student’s mathematical power and supports the class as a community of learners. The teacher provides students with the time necessary to explore mathematics and graph with significant ideas and problems. The physical space and materials are arranged and allocated so that students can work independently or collaboratively to make sense of mathematics. Students take intellectual risks by raising questions, sharing ideas, and formulating conjectures. The students display a sense of mathematical competence by validating and supporting ideas with mathematical arguments. |

| **2 - Improving Teaching** | 

The teacher regularly encourages students to learn to use mathematics to make sense of the world. The teacher fosters the development of each student’s mathematical power and supports the class as a community of learners. The teacher provides students with the time necessary to explore mathematics and graph with significant ideas and problems. The physical space and materials are arranged and allocated so that students can work independently or collaboratively to make sense of mathematics. Students take intellectual risks by raising questions, sharing ideas, and formulating conjectures. The students display a sense of mathematical competence by validating and supporting ideas with mathematical arguments. |

| **1 - Limited Teaching** | 

Some assigned problems require students to learn to use mathematics to make sense of the world. The class is usually taught in a direct instruction format. Usually the focus of the lesson is on skill attainment or learning mathematical procedures and algorithms. Sometimes the teacher assigns non-contextual problems. The physical space and materials are arranged and allocated in ways that structure students’ work. The teacher’s goal is to develop students’ procedural skills and proficiency. Students are required to practice during class and complete homework. The teacher often expects students to work independently and may use some collaborative groups. The teacher also asks students to show work on individual problems. Occasionally students are asked to share answers with the class. Students are encouraged to ask questions if they lack understanding.
Teacher's Role in Discourse

4 - Exemplary Teaching

The teacher orchestrates discourse in the class. The teacher poses questions and tasks that direct, engage, and challenge each student's thinking. The teacher listens carefully to the students' ideas and discerns mathematical meaning and relevance from student responses. Students are asked to clarify and justify their ideas orally and in writing. The teacher decides what to pursue in depth from among the ideas that students bring up during a discussion. Care is given by the teacher to develop concepts thoroughly and ensure students' ownership and understanding. The teacher decides when and how to return mathematical notation and language to students' ideas. The teacher has full understanding of the mathematical goals of the lesson and decides when to provide information, when to clarify an issue, where to model, when to lead, and when to let a student struggle with difficulty. These decisions are consistent with the goal and pace of the lesson. The teacher monitors students' participation in discussions and decides when and how to encourage each student to participate. These decisions are articulated so ensuring all students will learn and be successful in mathematics.

3 - Successful Teaching

The teacher often orchestrates discourse in the class. The teacher offers questions and tasks that direct, engage, and challenge each student's thinking. Often the teacher listens to the students' ideas and discerns mathematical meaning and relevance from student responses. Often students are asked to clarify and justify their ideas orally and in writing. The teacher may decide what to pursue in depth from among the ideas that students bring up during a discussion. Care is given by the teacher to develop concepts thoroughly and ensure students' ownership and understanding. The teacher decides when and how to return mathematical notation and language to students' ideas. The teacher has good understanding of the mathematical goals of the lesson and is often successful in determining when to provide information, when to clarify an issue, when to model, when to lead, and when to let a student struggle with difficulty. These decisions are often consistent with the goal and pace of the lesson. The teacher attempts to monitor students' participation in discussions and decides when and how to encourage students to participate. Attempts are made to reach all students.

2 - Improving Teaching

The teacher directs the class and attempts to foster discourse. Sometimes the teacher poses questions and tasks that direct, engage, and challenge students' thinking. The teacher listens to some of the students' ideas. The teacher may have difficulty following students' math thinking. Sometimes students are asked to clarify and justify their ideas orally and in writing. The teacher rarely deviates from the lesson plan to pursue ideas that students bring up during a discussion. Care is given by the teacher to develop concepts thoroughly and ensure students' ownership and understanding. The teacher attempts to return mathematical notation and language to students' ideas. The teacher has good understanding of the mathematical goals of the lesson. The teacher is often successful in determining when to provide information, when to clarify an issue, when to model, when to lead, and when to let a student struggle with difficulty. These decisions are often consistent with the goal and pace of the lesson. The teacher attempts to monitor students' participation in discussions and decides when and how to encourage students to participate. The instructional decisions may be digested with more standard and with the goal of covering the topics on the state test. The teacher considers expectations from student to student.

1 - Limited Teaching

The teacher directs the class. The teacher poses questions and tasks that focus students' work. The teacher may listen to some of the students' responses. The teacher may have difficulty following students' math thinking and usually ignores these responses. Rarely are students asked to clarify and justify their ideas orally and in writing. The teacher rarely deviates from the lesson plan to pursue ideas that students bring up during a discussion. The teacher usually follows the textbook in deciding when and how to return mathematical notation and language to students' ideas. The teacher has good understanding of the mathematical goals of the lesson. The instructional decisions may be digested with more standard and with the goal of covering the topics on the state test. The teacher considers expectations from student to student.

Students' Role in Discourse

4 - Exemplary Teaching

The teacher of mathematics promotes classroom discourse in which students take ownership and responsibility. Students listen to, respond to, and question the teacher and one another. The students use a variety of tools to reason, make connections, solve problems and communicate. Students often initiate problems and questions for the class to ponder and study. Students regularly make conjectures and present solutions. Students employ examples and counterexamples to investigate conjectures. Students try to convince themselves and one another of the validity of particular representations, solutions, conjectures and answers. Students rely on mathematical evidence and argument to determine validity. In small or large groups, students are an audience for one another's comments, explanations or questions. The discourse is focused on making sense of mathematical ideas and in using mathematical ideas sensibly in setting up and solving problems.

3 - Successful Teaching

The teacher of mathematics often promotes classroom discourse in which students take ownership and responsibility. Students often listen to, respond to and question the teacher and one another. The students use a variety of tools to reason, make connections, solve problems and communicate. Students often initiate problems and questions for the class to ponder and study. Students often make conjectures and present solutions. Students may employ examples and counterexamples to investigate conjectures. Students occasionally try to convince themselves and one another of the validity of particular representations, solutions, conjectures and answers. Students rely on mathematical evidence and argument to determine validity. In small or large groups, students are an audience for one another's comments, explanations or questions. The discourse is focused on making sense of mathematical ideas and in using mathematical ideas sensibly in setting up and solving problems.

2 - Improving Teaching

The teacher of mathematics tries to promote classroom discourse in which students take ownership and responsibility. Occasionally students listen to, respond to and question the teacher and one another. The students use a few tools to reason, make connections, solve problems and communicate. Students occasionally initiate problems and questions for the class to ponder and study. Students occasionally make conjectures and present solutions. Students occasionally employ examples and counterexamples to investigate conjectures. In a few situations, students rely on mathematical evidence and argument to determine validity. In small or large groups, students are occasionally an audience for one another's comments, explanations or questions. The discourse is focused on making sense of mathematical ideas and in using mathematical ideas sensibly in setting up and solving problems.

1 - Limited Teaching

The teacher of mathematics structures the discourse of the students. Often students are asked questions by the teacher and are expected to respond with answers. The students use a few tools to reason, solve problems and do math tasks. For specific assignments students create problems and questions for the class to do. Students are asked to present answers or solutions. Students learn and practice math procedures, vocabulary and facts. Occasionally students work in small groups on problems, discussing answers in large groups, students go over problems and solutions usually facilitated by the teacher. The discourse involves learning procedures and methods to solve problems and activities tomemorize facts and vocabulary.
Tools for Enhancing Discourse

4 - Exemplary Teaching

The teacher supports discourse and a positive learning culture by encouraging and supporting students to use tools to do and learn mathematics. The teacher supports the doing of mathematics in the manner that mathematics is done outside of school. The teacher values and encourages the use of a variety of tools such as computers, calculators, and other technology in addition to traditional paper and pencil and mental math. Students communicate orally and in writing using pictures, diagrams, tables, graphs, notation, symbols, narratives, metaphors, justifications and proofs. Students use models and concrete materials to make sense of mathematics and understand concepts. Students are responsible for selecting and using appropriate tools to solve and investigate problems. The teacher introduces conventional notation at points where doing so can further the work and the discourse at hand. Students are expected to communicate their conjectures, explanations, and arguments in a complete manner using appropriate tools.

5 - Successful Teaching

The teacher usually supports discourse by encouraging and supporting students to use tools to do and learn mathematics. Often the teacher values and encourages the use of a variety of tools such as computers, calculators, and other technology in addition to traditional paper and pencil and mental math. Sometimes the teacher asks the students to communicate orally and in writing using pictures, diagrams, tables, graphs, notation, symbols, narratives, metaphors, justifications and proofs. Students use models and concrete materials to make sense of mathematics and understand concepts. Occasionally students are responsible for selecting and using appropriate tools to solve and investigate problems. The teacher attempts to introduce conventional notation at points where doing so can further the work and the discourse at hand. Occasionally students are expected to communicate their conjectures, explanations, and arguments in a complete manner using appropriate tools.

6 - Improving Teaching

The teacher structures the tools that will adapt to the particular mathematics lesson. The teacher finds time to use computers and other technology. The teacher tries to balance the time when students use calculators, paper and pencil, and mental math. The teacher will, at certain times, encourage the students to communicate using pictures, diagrams, tables, graphs, notation, symbols, narratives, metaphors, justifications, and proofs. Students use manipulatives on appropriate activities. The teacher introduces conventional notation often. Occasionally students have had some kind of concrete experience or when the textbook suggests the students do so. Occasionally students communicate their solutions and explanations using a variety of tools.

1 - Limited Teaching

The teacher directs the class as to when they may use a certain mathematical tool. The teacher may do an activity with the computer or use it for those who either need practice or have finished their assignments. The teacher will allow students to use a calculator after they have shown they can calculate accurately using paper and pencil. The teacher directs the type of exercises expected such as charts, graphs, equations, or proofs. When called for in a lesson, the class may use manipulatives. The teacher regularly introduces the conventional notation to the class. There may be special projects or assignments where students communicate using alternative materials or tools.
APPENDIX D: MATH TALK LEARNING COMMUNITY RUBRIC

Evaluation Question #2b (second measure): Observations using “Math Talk Learning Community Rubric”
Source: *Journal for Research in Mathematics Education*, 2004

Components being rated from level 0 through 3:


2. Describing Levels and Components of a Math-Talk Learning Community

**Level D**

- **A. Questioning**: 
  - Teacher asks specific questions.
  - Teacher asks open-ended questions.
  - Teacher asks students to solve problems.
  - Teacher asks students to explain their thinking.
  - Teacher asks students to explain their strategies.

- **B. Explaining mathematical thinking**: 
  - Students explain their thinking.
  - Students explain their strategies.
  - Students explain their solutions.
  - Students explain their reasoning.

- **C. Source of mathematical ideas**: 
  - Students provide ideas.
  - Students provide solutions.
  - Students provide strategies.
  - Students provide explanations.

- **D. Responsibility for learning**: 
  - Students take responsibility for learning.
  - Students take responsibility for understanding.
  - Students take responsibility for reflecting.
  - Students take responsibility for communicating.

**Level C**

- **A. Questioning**: 
  - Teacher asks students to solve problems.
  - Teacher asks students to explain their thinking.
  - Teacher asks students to explain their strategies.

- **B. Explaining mathematical thinking**: 
  - Students explain their thinking.
  - Students explain their strategies.
  - Students explain their solutions.
  - Students explain their reasoning.

- **C. Source of mathematical ideas**: 
  - Students provide ideas.
  - Students provide solutions.
  - Students provide strategies.
  - Students provide explanations.

- **D. Responsibility for learning**: 
  - Students take responsibility for learning.
  - Students take responsibility for understanding.
  - Students take responsibility for reflecting.
  - Students take responsibility for communicating.

**Level B**

- **A. Questioning**: 
  - Teacher asks students to solve problems.
  - Teacher asks students to explain their thinking.
  - Teacher asks students to explain their strategies.

- **B. Explaining mathematical thinking**: 
  - Students explain their thinking.
  - Students explain their strategies.
  - Students explain their solutions.
  - Students explain their reasoning.

- **C. Source of mathematical ideas**: 
  - Students provide ideas.
  - Students provide solutions.
  - Students provide strategies.
  - Students provide explanations.

- **D. Responsibility for learning**: 
  - Students take responsibility for learning.
  - Students take responsibility for understanding.
  - Students take responsibility for reflecting.
  - Students take responsibility for communicating.

**Level A**

- **A. Questioning**: 
  - Teacher asks students to solve problems.
  - Teacher asks students to explain their thinking.
  - Teacher asks students to explain their strategies.

- **B. Explaining mathematical thinking**: 
  - Students explain their thinking.
  - Students explain their strategies.
  - Students explain their solutions.
  - Students explain their reasoning.

- **C. Source of mathematical ideas**: 
  - Students provide ideas.
  - Students provide solutions.
  - Students provide strategies.
  - Students provide explanations.

- **D. Responsibility for learning**: 
  - Students take responsibility for learning.
  - Students take responsibility for understanding.
  - Students take responsibility for reflecting.
  - Students take responsibility for communicating.

**Level 0**

- **A. Questioning**: 
  - Teacher asks students to solve problems.
  - Teacher asks students to explain their thinking.
  - Teacher asks students to explain their strategies.

- **B. Explaining mathematical thinking**: 
  - Students explain their thinking.
  - Students explain their strategies.
  - Students explain their solutions.
  - Students explain their reasoning.

- **C. Source of mathematical ideas**: 
  - Students provide ideas.
  - Students provide solutions.
  - Students provide strategies.
  - Students provide explanations.

- **D. Responsibility for learning**: 
  - Students take responsibility for learning.
  - Students take responsibility for understanding.
  - Students take responsibility for reflecting.
  - Students take responsibility for communicating.
Section C. *Current Interaction with non-Abacus teachers*

1. At this point in time, which, if any, non-Abacus teachers at your site view you (an Abacus teacher) as a mathematics education leader? Please list by those teachers’ initials (full names are not needed):

   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
   f. _____
   g. _____
   h. _____
   i. _____
APPENDIX F: INTERVIEW PROTOCOL

Step 1: Welcome

**Interviewer:**  Thank interview subject for taking time to meet with me.

Step 2: Connect with Prior Participation in the Abacus program

**Interviewer:**  Today I’d like to talk with you to learn more about your experience in the Abacus program. Now that the program has been completed, I’m interested in learning more about teachers’ experiences before, during, and after our meetings. As you may recall, you applied for the program approximately two years ago, and our first meeting was in March, 2016. Does that sound correct?

**Respondent:**  Respond, hopefully affirmative. If not, interviewer will ask for clarification.

**Interviewer:**  During Abacus, there were Saturday meetings with the whole group, after-school meetings at/near your school site, and there were summer institutes. Does this bring back some memories?

**Respondent:**  Respond, hopefully affirmative. If not, interviewer will ask for clarification. Respondent may offer some details, remembering their experience during the program.

Step 3: Elicit Favorite Aspects of Abacus

**Interviewer:**  What did you like best about Abacus?

**Respondent:**  Responds with one or more examples of what they liked about the program. If respondent does not remember anything they liked about Abacus:  Can you tell me more?

**Interviewer:**  Repeat question three times to elicit more ideas. (If no further ideas, move on).

Step 4: Elicit Evidence of Sustained Collaboration
Interviewer: I am interested in learning more about your work with others in the Abacus program. I think of collaboration here as any work you perform with a partner or group that is connected with your role as a teacher.

Respondent: Affirms

Interviewer
Follow Ups:

A. 1. Does a particular person from Abacus come to mind with whom you have collaborated regarding mathematics? (If it happens it was during group work and there were multiple people go with that and modify questions as shown below)
   2. Can you tell me about a conversation you had about math with____?
   3. Can you tell me more about this conversation you had?
   4. Did this conversation have any bearing on how you planned a math lesson? What about how you taught that lesson?
   5. (If yes, how did you feel about that lesson?)
   6. Did this conversation have any value for you beyond your planning and teaching of a particular lesson?
   7. IF yes, ask respondent to elaborate.
   8. (If it doesn’t come up, or isn’t clear to the interviewer ask a question: Do you recall if that was during a group activity, outside of Abacus, during partner work or after Abacus ended?)
   9. Can you think of another conversation you had with this person about math?

B. REPEAT QUESTION A MULTIPLE TIMES
   When there are no additional conversations to add, move on to Question C.

C. 1. What is it about this person (or persons) that makes you welcome collaboration with them? Why choose them? (If a group, why choose them?)
   2. How essential is this person(s) to the success of your planning and teaching?
   3. Are you still corresponding with _______ now that the program is over?
   4. If yes, tell me about what that looks like? About how recently did that occur (if it is not clear)?

REPEAT AND ASK ABOUT ANOTHER PERSON---Goal to get conversations with 3-4 people.
D. Did you complete extra coursework to earn your math added authorization (MIAA)?
   1. If yes, does a particular person come to mind with whom you collaborated during your MIAA courses?

If no, move on to Step 5.

2. Was this person in the Abacus program?
3. If yes (and not previously revealed during the interview), were there differences in the way you collaborated during Abacus and your MIAA courses?
   If no, skip to question 4.
4. Can you tell me about an assignment or project you worked on with this person?

REPEAT Section D, as needed, to determine if there were other MIAA collaborators.

Step 5: Elicit Perceptions Regarding Improvement to Collaborative Opportunities

Interviewer:  If you were in charge of Abacus, how would you have run the group work?

Respondent:  Describes what he/she would have done to facilitate group work. (Response may affirm what was already done during Abacus, or new ideas may surface).

Interviewer Follow Ups:
   A. If new ideas surface, ask:
      1. Can you tell me about your thinking?

   B. Repeat Question A to elicit more ideas, as needed.

Step 6: Elicit Perceptions Regarding Collaboration

Interviewer:  We’re getting close to the end of the interview, and I’m wondering if you have any other thoughts you’d like to add regarding collaboration during Abacus. Is there anything I’ve missed, or thoughts you’d like to add?

Respondent:  Provides additional information, if none, move on to Step 7.

Step 7: Elicit Perceptions Regarding the Program
Interviewer: When the Abacus program was designed, we expected roughly 10% of the teacher participants to drop out. But, in the end, we had a 100% completion rate. Why do you think this is the case?

Respondent: Explains thinking for 100% participant completion. If no information is shared, skip to Step 8.

Step 8: Wrap Up

Interviewer: Is there anything else you’d like to share?

Step 9: Thank participant for completing the interview.