A MIXED METHODS STUDY OF CRITICAL COLLEAGUESHIP AS SUSTAINABLE SUPPORT FOR ELEMENTARY MATHEMATICS LEADERS

by
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Abstract

Teaching mathematics, especially in urban elementary schools, is a complex endeavor requiring specialized, expert level knowledge of mathematics, pedagogy, and student development. Drawing from social cognitive theory (Bandura, 1986) and social capital theory (Leana & Pil, 2006), this study within the elementary schools in an urban New England school district explores the inter-relationships of mathematics knowledge for teaching, mathematics efficacy for teaching, professional support networks, and contextual factors, as elements found to influence instructional effectiveness and student mathematics achievement. Based on needs assessment data that indicated weak perceptions of collective mathematics efficacy for teaching, connected to a lack of collegial trust, an intervention was implemented to develop critical colleagueship among the district's school-based, elementary mathematics coaches as sustainable support for collective mathematics efficacy for teaching and professional growth, through active engagement in collaborative inquiry teams within a blended learning environment. A mixed methods analysis of process and outcome data indicated statistically significant, positive changes to participants' perceptions of collective mathematics efficacy for teaching and internal social capital. Findings indicate focusing future professional development efforts for school-based instructional leaders on promoting internal social capital may be an effective approach to promoting collaborative and sustainable professional learning, as well as students' mathematics achievement.

Keywords: Elementary mathematics education, collective efficacy for teaching, internal social capital, collegial trust, mathematics knowledge for teaching, professional support networks, social cognitive theory, social capital theory, critical colleagueship, instructional leaders

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Executive Summary

Elementary teachers, especially in urban districts, struggle to support students' development of the deep mathematics understanding needed to critically reason about mathematics content, contexts, and problems (Ma, 2010). As a result, many students leave elementary school unprepared for higher level mathematics classes and ultimately, they may lack the critical thinking skills and strategies required in today's job market (Condron, Tope, Steidl, & Freeman, 2013; Eisner, 2010; Miles & Baroody, 2012). Libertyville (a pseudonym), the focus of this study, is an urban school district in New England where this problem is evident. Libertyville K-12 public schools serve approximately 24,000 students, the majority of whom (85%) reside in low income households with many (60%) being recent immigrants in homes where English is not the primary language spoken. Standardized test data from the past decade reveal that only a small percentage of district students are proficient or above in mathematics, with proficiency rates averaging under 20% for elementary students, roughly 10% for middle school students, and under 5% for high school students ('State' Department of Education, 2016). Although these rates are based on a single standardized assessment, the low proficiency rates appear to indicate that few Libertyville students are leaving high school prepared for the critical thinking and reasoning demands of the 21st century job market and globalized society.

Analysis of Underlying Factors

Instructional quality directly impacts students' mathematics achievement (Chetty, Friedman, & Rockoff, 2014; Downey, von Hippel, & Broh, 2004; Gamoran & Long, 2006). Effective mathematics instruction that promotes conceptual understanding, critical thinking, and reasoning for diverse groups of elementary students requires that teachers have deep knowledge of mathematics content, pedagogy, and student development (Ball, Thames, & Phelps, 2008;

Hill, 2007; Shulman & Sherin, 2004; Wilson, Mojica, & Confrey, 2012). This deep and flexible mathematics knowledge for teaching is not fully developed in teacher training programs, but instead develops and transforms over time through peer interactions and job-embedded learning experiences (Ma, 2010). Bandura's (1986) social cognitive theory and the notion of triadic reciprocal determinism, purports that development of expert level knowledge and the reconceptualization of practice require sustained and substantive social construction of knowledge (Truscott, Bolling, Graybill, Albritton, & Schwartz, 2012; Wilson & Berne, 1999).

A literature review and district needs assessment explored the influence of four categories of factors on teacher mathematics learning and instructional decision making at the school and district level: (a) relationships and resource exchanges within professional support networks; (b) contextual factors within and across schools, including structures, systems, and student demographics; (c) teachers' mathematics knowledge for teaching (MKT); and (d) teachers' individual and collective mathematics efficacy for teaching (MEFT); (Bandura, 1986; Ernest, 2010; Francis, 2009; Shulman & Shulman, 2004). An analysis of needs assessment questionnaire and survey data indicated a lack of collegial trust, inefficient knowledge and resource exchanges, and weak perceptions of collective mathematics efficacy for teaching (C-MEFT) were impeding the district's capacity to promote students' mathematics achievement and ongoing professional learning and growth.

These needs assessment findings are important because Visible Learning research indicates teachers' perceptions of their collective efficacy for teaching, defined as their beliefs of students' achievement potential and their collective capacity to promote student achievement, have been found to have a more significant effect on students' success than any other personal or contextual factor (Donohoo, Hattie, & Eels, 2018). The potential impact of strong collective efficacy for teaching perceptions coupled with findings of moderate perceptions of collective capacity and weak interschool relationships in this district indicated that creating structures and supports to strengthen professional support networks across district schools was a potentially effective solution to supporting students' mathematics achievement by promoting collegial trust, shared vision, and more effective and efficient resource exchanges (Coburn et al., 2012; Frank, Zhao, Penuel, Ellefson, & Porter, 2011; Shulman & Shulman, 2004). These change efforts involved shifting professional development design away from a top-down infusion of skills and knowledge to instead building upon existing social, human, and physical capital in the district as sustainable support for organizational capacity to promote both student mathematics achievement and educators' ongoing professional growth (Cosner, 2009; Minckler, 2014; Wilson & Berne, 1999).

Promoting Opportunities for Critical Colleagueship

Social cognitive and social capital theorists propose that social interactions promote learning and change motivation (Bandura, 1986; Minckler, 2014). Critical colleagueship, the promotion of professional collaborative, critical analysis of existing instructional practices and beliefs, amplifies this effect (Lord, 1994; van Es, 2012). Based on these theoretical and empirical foundations, Libertyville's 20 elementary mathematics coaches were provided opportunities to develop critical colleagueship and strengthen perceptions of both collective mathematics efficacy for teaching (beliefs about collective capacity to teach mathematics and promote student learning) and internal social capital (beliefs about the value of professional relationships and the resources exchanged through those networks (Booth, 2012; Cosner, 2009; Kintz, Lane, Gotwals, & Cisterna, 2015; Vavasseur & MacGregor, 2008) through engagement in structured, collaborative inquiry teams.

Key design elements aimed at promoting agency, collegial trust, and motivation for change enactment (Anderson, 2008; Cosner, 2009; Eyal & Roth, 2011; Rock & Cox, 2012, Valli & Buese, 2007) included: (a) alignment of inquiry team goals and structures to existing district structures and priorities, (b) autonomy within collaborative inquiry teams for goal setting and action planning, (c) attention to team development through the establishment of team charters for collaborative norms, and (d) the use of a blended design to promote regular interaction through both in-person and virtual meetings and asynchronous, online collaboration. Together these elements enhanced opportunities for trust development and created social learning conditions conducive of positive perceptions of collective capacity for supporting both educators' and students' achievement and growth (DuFour, 2016; Hattie, 2018).

Findings of Changed Perceptions

This study's evaluation examined the influence of critical colleagueship development on these elementary mathematics coaches' perceptions of collective mathematics efficacy for teaching (C-MEFT) and internal social capital (ISC) value, unlike the evaluation of many professional development efforts that focus on knowledge acquisition and strategy implementation (Abrami et al., 2011; Linder et al., 2013). This evaluation focus was based on the theory that structured, practice-based collaboration with inter-school colleagues supports development of professional relationships that have the breadth and depth needed to diffuse information and resources throughout an organization (internal social capital) and to ultimately result in enhanced organizational capacity (Lord, 1994; Minckler, 2014).

Findings indicated a significant, positive change to both collective mathematics efficacy for teaching (C-MEFT) and internal social capital (ISC) perceptions for this population of 20 elementary mathematics coaches. This change indicates these elementary mathematics coaches developed more positive perceptions of the collective ability of educators across the district to effectively teach mathematics, to promote students' mathematics achievement, and to support and distribute human and structural capital within and across schools. Triangulated with data from analysis of discussion content and collaborative inquiry team engagement, findings suggest that participants found value in the collaborative inquiry process, including opportunities to strengthen inter-school relationships, deprivatize their practice, and establish common understanding of expectations for mathematics teaching and learning across district schools.

Implications for Practice

Examination of participants' collaborative inquiry engagement and critical colleagueship development suggest change efforts, such as the development of professional learning systems that promote collaborative learning and strengthen perceptions of C-MEFT and ISC, may be supported by (a) the formation of a powerful guiding coalition, (b) establishment and communication of a clear vision, (c) empowerment of individuals to act upon that vision, and (d) the creation of short-term wins to sustain motivation (Kotter, 1995). In educational settings, forming an effective guiding coalition requires distributed leadership across three levels: peer leaders within schools (such as the mathematics coaches), system-wide instructional leaders (such as mathematics curriculum and instruction specialists), and school-based principals (Loucks-Horsley & Matsumoto, 1999). Failing to effectively engage stakeholders from any one of these levels can result in a lack of alignment and buy-in, negatively influencing collaboration and collective efficacy development (Goddard, Goddard, Kim, & Milller, 2015). Guiding coalitions will only successfully promote organizational capacity development and change enactment if they are able to effectively communicate a clearly established and agreed upon vision throughout the organization. Kotter (1995) suggests clear communication must go beyond words and leverage all forms of communication including daily activities and policy development. These actions include eliminating structural and systemic barriers to individual empowerment, to ensure time and opportunity are available for experimenting with and discussing new ideas both individually and collaboratively, as well as promoting agency around practice-based collaborative inquiry (Calvert, 2016; Donohoo & Katz, 2017). And finally, because change enactment occurs incrementally over time, professional development efforts should include the development of short-term wins that are specific, actionable, and measurable to promote sustained motivation, especially when difficulties arise (Jensen et al., 2016; Kotter, 1995). The combination of these four elements (a guiding coalition, clear vision, empowerment, and short-term goals) help to decentralize leadership, promote interdependence among stakeholders, and help create the team dynamic that characterizes effective professional learning systems (DuFour, 2016).

Conclusion

In conclusion, this study's findings indicate the potential for enhancing school districts' capacity to promote perceptions of collective mathematics efficacy for teaching and internal social capital through critical colleagueship development within inter-school professional support networks. However, findings also indicate that leveraging organizational capacity requires carefully balancing autonomy and professional learning structures to enable development of individual empowerment and professional cohesion, while also aligning change efforts to existing district professional learning structures and teaching and learning priorities and by providing skilled facilitation to ensure equitable engagement and sustained impact on overall organizational capacity (Donohoo, 2017; Eyal & Roth, 2011; Rock & Cox, 2012).

Chapter 1: Problem of Practice Literature Review

In 2010, the National Governors Association Center for Best Practices and Council of Chief State School Officers (CCSSO) released the *Common Core State Standards for Mathematics* as a foundation for K-12 public school districts in the United States to support the development of a coherent and rigorous curriculum to ensure all students leave high school with the knowledge and skills needed for success in college, career, and life. The impetus for these standards and their subsequent adoption by 42 states included a lack of qualified applicants for high-skill jobs, comparatively poor mathematics performance by U.S. students on international assessments, and persistent achievement gaps between subpopulations of students in this country (Bali & Alvarez, 2004; Condron et al., 2013; Downey, von Hippel, & Broh, 2004; Eisner, 2010).

The depth and complexity of mathematics skills and knowledge needed to successfully meet the demands of modern life are becoming increasingly complex (Darling-Hammond, 1997; Eisner, 2010; Miles & Baroody, 2012; Tyack & Cuban, 1995). Not only is mathematics knowledge the basis of scientific and technological breakthroughs, it also supports one's ability to think independently, engage in academic discourse, and apply skills and understanding to unfamiliar contexts (Eisner, 2010; Kirwan, 2001). These are skills needed to thrive in today's economy and that are lacking in high school and college graduates in the U.S. Eisner's (2010) econometric analysis of U.S. business and job websites revealed the 15 highest earning and most in demand college degrees all require significant mathematics skills, but only 4% of the degrees earned nationwide were awarded in these areas.

In U.S. schools, this mathematics knowledge deficit becomes more pronounced in higher grades and is greater for students holding lower socio-economic (SES) and minority status. International assessments such as the Trends in International Mathematics and Science Study

(TIMSS; http://timssandpirls.bc.edu/) as well as national assessments such as the National Assessment of Educational Progress (NAEP; https://nces.ed.gov/nationsreportcard/) show a downward slide in student achievement between fourth and eighth grade, and lower achievement for particular groups, including Black and Hispanic students, students of lower SES households, students with identified learning disabilities, and English Language Learners (National Center for Education Statistics, 2012, 2015).

Problem of Practice in Context

State and local assessment data from many public-school districts, especially those in urban areas, reveal these same patterns. The New England state where this study was situated is one such example. On the 2015 Partnership for Assessment of Readiness for College and Career (PARCC) mathematics assessment, 25% of students in this state, across all grade levels, scored in the proficient or above category; however, there was a decline in mathematics proficiency from 36% for grade three students to 26% of middle school students and only 12% of high school students. This same report indicated that in urban districts, such as the Libertyville Public School District (a pseudonym) where this current study takes place, only 12% of all students, about half of the state average, scored proficient or above. There was also a decline in student performance in Libertyville from elementary school (18%) to middle school (11%) to high school where only 4% of students scored proficient or above in mathematics. Further, lower scores were found for students with IEPs (4% proficient), English Language Learners (ELLs) (6%), and Black and Hispanic students (11%). These trends are not unique to the district's use of this new standardized test (PARCC), achievement gaps and overall low performance for these sub-populations have been evident in the state and this district for more than a decade ('State' Department of Education, 2015).

Conceptual Framework

The declining percentage of proficiency on state mathematics assessments as students move from elementary to middle school is the focus of this study. These proficiency data may support the premise that the upper elementary teachers, grades three through five, in the Libertyville Public School District struggle to meet the learning needs of their students and are challenged to prepare them effectively for subsequent success in middle school mathematics and ultimately the demands of the 21st century's knowledge economy.

Student mathematics achievement is directly related to the quality of classroom instruction (Chetty, Friedman, & Rockoff, 2014; Downey, von Hippel, & Broh, 2004; Gamoran & Long, 2006). Effective mathematics instruction with diverse groups of elementary students is a complex endeavor shaped by teacher mathematics knowledge for teaching (MKT; Ball, Thames, & Phelps, 2008; Hill, 2007; Ma, 2010; Shulman & Sherin, 2004; Smith, Desimone, & Ueno, 2005), individual and collective mathematics efficacy for teaching (MEFT; Bandura, 1986; Pajares, 1996), professional support networks (Coburn & Russell, 2008; Darling-Hammond, 2003), and contextual factors within the school organization (Cobb & Jackson, 2015; Shulman & Shulman, 2004; Figure 1.1).

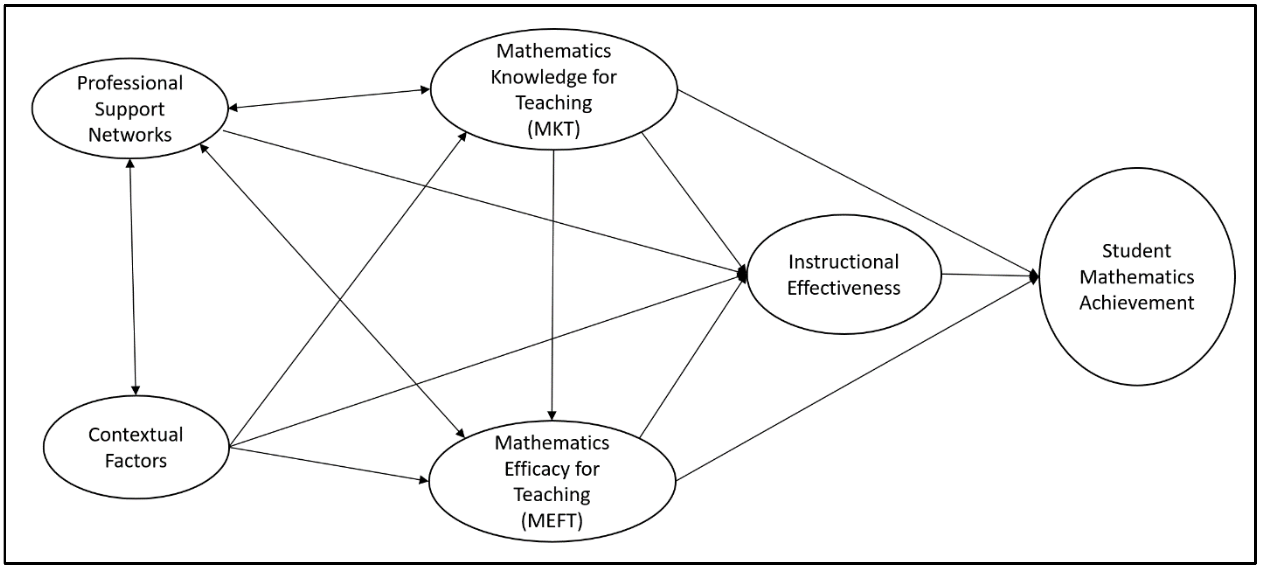


Figure 1.1. Conceptual framework of key underlying factors of problem of practice.

Content and Pedagogical Knowledge for Teaching Mathematics

Mathematics knowledge for teaching (MKT) is not reflective of the knowledge developed in collegiate mathematics department courses nor that used in other mathematics related fields (Ball, Thames, & Phelps, 2008; Ma, 2010; Speer, King, & Howell, 2014). Teachers' specialized content knowledge (SCK) must include an understanding of not just the 'that' of mathematics content, but also the 'why,' in other words the organizing principles, structures, and rules of the field (Ball, Thames, & Phelps, 2008; Ma, 2010; Shulman, 1986). Additionally, MKT must include pedagogical content knowledge (PCK) that enables "making mathematical sense of student work and choosing powerful ways of representing the subject so that it is understandable to students" (Ball, Thames, & Phelps, 2008, p. 404). And finally, this deep and flexible knowledge must include an understanding of both the lateral and vertical connections between key concepts, an aspect referred to as HCK or horizon content knowledge (Thames & Ball, 2010).

Taken together, SCK, PCK, and HCK provide a *profound understanding of fundamental mathematics* (PUFM), giving teachers the "capability to 'pass through' all parts of the field – to weave them together" (Ma, 2010, p. 121) and guide development of student understanding through effective instructional practices (Figure 1.1). MKT is not fully developed during teacher preparation coursework but instead develops on the job through peer interactions, formal training opportunities, and study of curricular materials (Ma, 2010). Teachers in schools lacking social support and/or professional development opportunities struggle to develop MKT and teaching confidence, leaving them less able to meet student mathematics learning needs (Figure 1.1).

Mathematics Efficacy for Teaching

In addition to levels of MKT, teachers' individual and collective confidence in their ability to teach mathematics and support student knowledge growth and performance, or mathematics efficacy for teaching (MEFT), impacts instructional effectiveness (Figure 1.1). Positive MEFT perceptions increase teachers' effort, persistence, perception of challenges, and sense of responsibility for student learning (Goddard, Hoy, & Woolfolk Hoy, 2000). As a result, MEFT is a predictor of student achievement (Figure 1.1), often offsetting other factors such as socio-economic status (SES) and prior achievement (Bandura, 1993; Goddard et al., 2000).

In line with expectancy value theory, teachers' MEFT perceptions are shaped by outcome expectations of both attainment and affective abilities within a specific context (Bandura, 1986; Pajares, 1996; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). This also holds true for collective efficacy, defined as "perceptions of teachers in a school that efforts of the faculty as a whole will have a positive effect on students" (Goddard et al., 2000, p. 480), as well as for perceptions of individual efficacy. MKT both influences and is impacted by teachers' MEFT perceptions and both knowledge and efficacy are influenced by contextual factors, such as organizational climate and resources, as well as by professional support networks (Figure 1.1) (Darling Hammond, 1997; Goddard et al., 2000; Shulman & Shulman, 2004).

Contextual Factors

According to triadic reciprocal causation, MEFT results from the interplay between personal factors, behavior, and environmental influences (Figure 1.1), which together lead to beliefs about one's ability to exercise control and personal agency within a particular context (Bandura, 1986; Pajares, 1996). Contextual factors within school organizations include student characteristics, availability of instructional materials, physical facilities, and professional community (Goddard et al., 2000). "When teachers believe they are members of a faculty that is both competent and able to overcome detrimental effects of the environment, the students in their building have higher achievement scores" (Goddard et al., 2000, p. 29). However, even with strong collective efficacy, success may be constrained by inadequate organizational infrastructures, teacher expertise, or emotional climate (Pajares, 1996; Figure 1.1).

Institutional policies, such as budgeting related to staffing and materials, determine the mobilization of and access to both human and social capital. This allocation in turn impacts instructional effectiveness and professional growth (Spillane & Thompson, 1997), as well as how effectively individuals work together to solve problems and develop shared mathematics knowledge for teaching capacity (Coburn, Mata, & Choi, 2013). Policies also impact autonomy, or teachers' sense of control, over professional decision making for mathematics teaching and learning within their own classrooms. High stakes testing and increased accountability have disempowered teachers, lowering both motivation and MEFT, whereas leadership that promotes shared responsibility increases knowledge sharing and collective MEFT leading to greater student achievement (Daly, Moolenaar, Bolivar, & Burke, 2009; Jaquith, Mindich, Wei, & Darling-Hammond, 2011).

Professional Support Networks

Social cognitive theory posits that individuals learn through social interactions (Bandura, 1986; Coburn et al., 2013). Professional support networks (Figure 1.1) "provide access to information and expertise to support [professional] learning and foster the depth of interaction that may be necessary for teachers to grapple with new approaches in ways that help them question their assumptions and reconfigure their instructional practice over time" (Coburn & Russell, 2008, p. 223) and develop the adaptive mathematics knowledge for teaching needed to promote student success.

All professional interactions between educators, however, are not equal. To effectively support knowledge development and instructional change, interactions must be characterized by strong social ties, trust, and expertise (Coburn & Russell, 2008). And it is an individual's location within professional support networks (Coburn, Russell, Kaufman, & Stein, 2012) that determines how that individual draws upon available resources to achieve desired outcomes (Coburn & Russell, 2008).

Teachers with more knowledge and who work in supportive educational environments have more positive MEFT perceptions, are more likely to feel prepared to teach mathematics, and are the most apt to invest in learning about and using instructional strategies aimed at preparing students for success in the 21st century economy (Hill, 2010; Smith et al., 2005). In turn, positive collective MEFT perceptions support efficient exchange of professional knowledge, curricular resources, lesson planning ideas, student achievement data, and other teaching and learning resources, and contribute to effective patterns of social relationships leading to collective action, goal achievement, and improved instructional practices (Moolenaar, Sleegers, & Daly, 2012).

Qualitative comparative studies have shown organizations can leverage the power of teachers' social and professional relationships to enact change by developing a professional community characterized by shared vision, shared knowledge base, community of practice, shared commitment, and support (Coburn et al., 2012; Coburn, et al., 2013; Frank, Zhao, Penuel, Ellefson, & Porter, 2011; Shulman & Shulman, 2004). Social network analysis shows that "when teachers believe they are members of a faculty that is both competent and able to overcome detrimental effects of the environment, the students in their building have higher levels of achievement" (Goddard et al., 2000, p. 29).

It is, however, important to note that if individuals within professional support networks are lacking knowledge, skills, motivation, or adequate support, interactions within these networks are weakened and instructional effectiveness is impeded (Shulman & Shulman, 2004) (Figure 1.1). Although strong evidence exists that teachers' mathematics content and pedagogical knowledge is a key component to student mathematics achievement (Darling-Hammond, 1997), researchers have struggled to develop a clear definition of what types of teacher knowledge are needed, how they are used, or how to assess individual expertise for each aspect (Hill, 2007; Smith et al., 2005; Wilson & Berne, 1999).

Mathematics Knowledge for Teaching

Lee Shulman (1986) was one of the first researchers to take on the challenge of developing a clear operational definition for the mathematics knowledge needed for teaching. Through an exploration of a century's (1875 – 1985) worth of teacher certification examination questions, he determined that the emphasis of teacher training was polarized during different periods in history, reflecting a focus on either content knowledge or general pedagogy. He proposed that teacher examinations, and thus teacher preparation, need to "reflect those fundamental connections between knowing and teaching" (p. 5) and asserted "that both content and process are needed by teaching professionals, and teacher preparation and examination content must include knowledge of the structures of one's subject, pedagogical knowledge of the general and specific topics of the domain, and specialized curricular knowledge" (p. 10). Shulman further defined teacher knowledge by proposing three categories of content knowledge: (a) subject matter content knowledge including both the *that* and the *why* of the discipline, (b) pedagogical content knowledge (PCK) including knowledge of how to make content accessible to learners by reorganizing their prior understanding, and (c) curricular knowledge including knowledge of the indications and contraindications of available programs and materials as well as knowing how to connect present concepts to other parts of the curriculum (Shulman, 1986).

Refining the Definition of MKT

Building upon Shulman's (1986) work, Ball and colleagues (2008) describe mathematics knowledge for teaching (MKT) as including both subject matter knowledge and pedagogical content knowledge (Figure 1.2). They explain that subject matter knowledge, the knowledge used for sizing up mathematics issues and explanations, is comprised of (a) common content knowledge (CCK), mathematics knowledge used in a variety of settings; (b) specialized content knowledge (SCK), mathematics knowledge used specifically for teaching others; and (c) horizon content knowledge (HCK), mathematics knowledge of what has come before and what is coming next in the curriculum (Thames & Ball, 2010). They break down Shulman's (1986) concept of PCK, mathematics knowledge used in making instructional decisions, into knowledge of content and students (KCS), knowledge of content and teaching (KCT), and curriculum knowledge (Ball, 1990; Ball, Thames, & Phelps, 2008; Speer, King, & Howell, 2014).

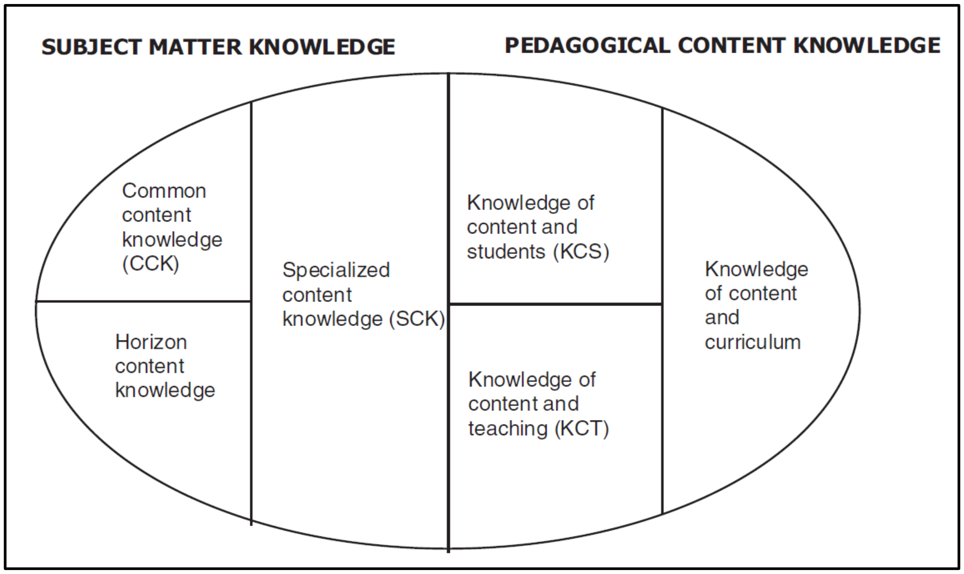


Figure 1.2. Domains of mathematical knowledge for teaching. Reprinted from “Content knowledge: What makes it special?” by Ball, D., Thames, M.H., & Phelps, G., 2008, *Journal of Teacher Education, 59*(5), p. 403. Copyright 2008 by Sage Publications.

A Need for Expert Knowledge

MKT, therefore, represents a mixture of professional understanding of content, students, and teaching (Ball et al., 2008) and therefore is not reflective of the type of knowledge developed in traditional mathematics content courses or that used by mathematicians in other fields (Ball, 1990; McCrory, Floden, Ferrini-Mundy, Reckase, & Senk, 2012; Shulman, 1986; Speer et al., 2014). Effective teachers must have high levels of both general mathematics content knowledge as well as knowledge of how to strategically make that content accessible to a wide range of students (Darling-Hammond, 1997; Hill, 2007; Hill et al., 2005; Shulman, 1986; Shulman & Sherin, 2004; Shulman & Shulman, 2004; Wilson, Mojica, & Confrey, 2012).

This expert level thinking (Schmittau, 2004) or what Ma (2010) called PUFM, profound understanding of fundamental mathematics, involves the ability to decompress and trim content to match students' levels of readiness and to bridge concepts to past and future topics to support student understanding (McCrory et al., 2012). In other words, teaching mathematics requires efficient and fluent analysis of errors and non-standard approaches, explanation of the rationale for procedures and terminology, anticipation of misconceptions, unpacking student thinking, and understanding which representations will provide students with the best explanations of larger mathematics concepts and principles (Ball et al., 2008; Green, 2014; Shulman, 1986).

Applying Complex Knowledge

Mathematics teachers must not only be able to do the mathematics but also explain what is being done and why (Ma, 2010). PCK includes an understanding of how knowledge is generated and structured and thus enables educators to make the subject comprehensible by anticipating confusions, interpreting students' emerging ideas and naïve conceptions, strategically sequencing tasks, analyzing the advantages and disadvantages of different representations, and coordinating instructional options and purposes (Ball et al., 2008). As a result, teachers with high levels of PCK can support the refinement of students' thinking, and connect this understanding to future topics (Linn, Lewis, Tsuchida, & Songer, 2000), the type of mathematics knowledge students need for success in middle and high school mathematics courses and the 21st century economy.

Specialized content knowledge (SCK) is a branch of pure content knowledge that includes knowing the "organizing principles, structures, and rules of a field" (Ball et al., 2008, p. 396) that make up both lateral and vertical curriculum knowledge (Ball et al., 2008). Developing SCK entails unpacking the mathematics to determine patterns in errors, different interpretations of operations, different types of word problems, how to match a story problem to a particular type of calculation, and explicit knowledge of how mathematics terms hold different meanings in different contexts (Ball et al., 2008; Leinhardt & Smith, 1985; Wilson et al., 2012).

It is "not always easy to discern where one of [the knowledge] categories divides from the next" (Ball et al., 2008, p. 403). The type of knowledge being used is determined by the prior experiences and perspective of the individual teacher and the specific learning context. For example, when analyzing a student error, a teacher would use SCK if they were analyzing the underlying mathematics steps or assumptions, but they would use KCS if this error was one they had seen from students before. Additionally, a single instructional task often requires multiple types of knowledge, for example when developing student understanding of decimals, a teacher would need CCK to determine the correct ordering of a list of decimals, SCK to generate an appropriate list of decimals to be ordered by students within an instructional task, KCS to recognize which ones will cause students the most difficulty, and KCT to determine subsequent instructional strategies when these difficulties arise (Thames & Ball, 2008).

Recognizing this complexity, Ma (2010), in her comparative study of mathematics teachers in the United States and China, explains four overriding properties of understanding: basic ideas, connectedness, multiple representations, and longitudinal coherence. Together these properties help teachers organize their mathematics knowledge into *packages* that enable them to explicitly connect procedural topics, conceptual topics, and basic principles. She explains that an understanding of the "relationships among the four operations [through these four overriding properties], then becomes a road system that connects all of elementary mathematics. With this road system, one can go anywhere in the domain." (p. 113). Ma (2010) describes PUFM, or the profound understanding of mathematics, as having three components: (a) depth or the ability to connect “conceptually powerful ideas,” (b) breadth or the ability to “connect [ideas] with those of similar or less conceptual power,” and (c) thoroughness or the “capability to ‘pass through’ all parts of the field…weave them together…[and] ’glue’ knowledge of mathematics into a coherent whole” (p. 121).

Ma (2010) concludes that a “teacher’s map of school mathematics must be more complicated and flexible” (p. 123) than that of mathematicians in other fields. It must include connectedness, multiple perspectives, basic ideas, and longitudinal coherence. Teachers must be aware of simple but powerful mathematics ideas that can serve as road signs that guide development of student understanding.

The Impact of Teacher Knowledge on Student Learning

Teacher knowledge influences all decisions made in the classroom and accounts for much of the variation in student achievement (Chetty, Friedman, & Rockoff, 2014; Darling-Hammond, 1997; Downey et al., 2004; Gamoran & Long, 2006; Hanushek & Rivkin, 2010; Koppich, 2000). Using data collected from school district and U.S. tax system records for more than a million students, Chetty and colleagues (2014) found that having a teacher who lacks adequate skills and knowledge has the same detrimental impact on student achievement as being absent for one-third of the school year. Conversely, having a high-quality teacher for even one year has a significant positive impact not only on test scores, but also on long-term factors such as college attendance and annual earnings. A negative relationship between student minority status and teachers’ level of specialized content knowledge (Hill et al., 2005; Moolenaar et al., 2012) coupled with a belief by teachers in the U.S., unlike those in other high achieving nations, that conceptually based instruction is only appropriate for high achieving students (Desimone et al., 2005) has led to inequitable access to high quality mathematics instruction and a persistent achievement gap between lower-SES, minority students and their more affluent, non-minority peers (Bali & Alvarez, 2004; Condron et al., 2013; Downey et al., 2004; Ganesh & Middleton, 2006; Hines, 2008; Padron, Waxman, Lee, Lin, & Michko, 2012). The Coleman report (Coleman et al., 1966) found that compared to their more affluent peers, students in low SES and minority groups are more impacted by school and teacher quality, characteristics which continue to be lower in the segregated, urban districts, like Libertyville, where these students often attend school (Darling-Hammond, 1997; Downey et al., 2004).

Adaptive knowledge. Teachers use their specialized mathematics knowledge to respond quickly, accurately, and flexibly to student ideas as they work to match instruction to students' levels of readiness (thinking and behavior) and to bridge present concepts to past and future topics (learning trajectories) to make mathematics coherent and meaningful (McCrory et al., 2012; Wilson et al., 2012; Wilson, Sztajn, Edgington, & Confrey, 2013). Ma (2010) found that "teachers with PUFM never ignore the role of 'procedural learning' no matter how much they emphasize 'conceptual understanding'" (p. 153). This supports the finding that teachers with low levels of knowledge are often unable to help their students make clear connections between concrete representations and abstract concepts and procedures. Teachers may also be apt to abandon this step in building conceptual understanding, instead feeling pressured to prepare students for paper and pencil, calculation focused assessments (Grant, Peterson, & Shojgreen-Downer, 1996).

Higher teacher knowledge scores have been connected to higher quality lessons, including teacher's clear explanations, effective use of representations, and productive interactions with student thinking that result in increased academic growth for students. This finding provides further support for teachers' SCK and PCK expertise as better indicators of student achievement than proxy measures such as years of teaching experience or credentials (Cobb & Jackson, 2015; Hill, 2007; Hill et al., 2005). An increase in knowledge and confidence manifests in teachers' willingness to move away from strictly adhering to textbook lessons, as they include more open-ended questioning to probe and extend thinking, encourage discourse and negotiation of meaning, and expect higher levels of thinking from all students (Smith et al., 2005; Swafford, Jones, & Thornton, 1997).

In her observations of mathematics instruction, Green (2014) noticed that effective implementation of instructional strategies was impeded not by "a lack of will, but a lack of clarity about what to do…without the mathematical training to respond to students' comments, [teachers] weren't able to translate confusion into understanding" (p. 105). Ma (2010) also supported this observation concluding that when teachers are unable to accurately analyze the thinking behind student responses, the significance of conceptions and misconceptions are often overlooked, leaving both teacher and student feeling disempowered and wondering why success has not been achieved.

Mathematics Efficacy for Teaching

An individual's knowledge, skills, and beliefs influence their instructional vision, understanding, practice, and motivation (Shulman & Shulman, 2004; Figure 1.1). Many U.S. teachers view mathematics as a collection of facts and rules and see mathematics ability as an innate, fixed intelligence (Bandura, 1986; Davison & Mitchell, 2008). Thus, they have a limited knowledge of the concepts and principles that comprise mathematics believing that understanding merely involves the ability to restate rules and use standard algorithmic procedures correctly (Ball, 1990; Leinhardt & Smith, 1985; Ma, 2010). A coherent knowledge, including an understanding of the connections between mathematics concepts and between algorithms and the underlying rules and relationships that make them work, or SCK, is necessary for "making sense of student work and for choosing powerful ways of representing the subject so that it is understandable to students," or PCK (Ball et al., 2008, p. 404). The accompanying shift of focus from correctness to determining which aspects of a concept a student understood and where to go next (Blomeke, Buchholtz, Suhl, & Kaiseer, 2014; Wilson et al., 2012) has been found to be a strong focus in high achieving countries such as China and Japan, but not in the U.S. (Cai, Ding, & Wang, 2014; Linn et al., 2000; Ma, 2014). Without adequate levels of MKT, it is unlikely that teachers will develop the instructional practices needed to implement current mathematics standards and promote students' reasoning and sense making skills, knowledge, and habits of mind required for 21st century jobs (Blomeke et al., 2014; Darling-Hammond, 1997; Smith et al., 2005; Figure 1.1).

Individual Efficacy for Teaching

Feelings of preparedness to teach mathematics, a facet of individual mathematics efficacy for teaching (MEFT) perceptions, are strong indicators for the use of the conceptually based instructional strategies (Smith et al., 2005) needed to effectively support students' mathematics understanding. Many teachers in the U.S. have negative individual MEFT perceptions, defined as personal beliefs in one's ability to be successful with a task or the level of competence one expects to attain (Datnow, Hubbard, & Mehan, 2002). Ball (1990) found that many prospective elementary educators lacked confidence in their mathematics ability, did not like mathematics, and even avoided it when possible.

According to social cognitive theory individual efficacy is comprised of two components (Bandura, 1986). The first is self-efficacy or attainment ability for a specific task. This determines a teacher's perception of how effectively they will be able to teach a given concept or topic in a specific context, including with a particular group of students. The second is outcome expectancy, defined as a teacher's perception of the impact their instruction will have on student achievement (Bandura, 1997; Buss, 2010; Goddard et al., 2000; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). This view of individual efficacy is grounded in Rotter's (1967) locus of control theory which describes the extent one believes they can control reinforcement of actions or student achievement and Bandura's (1986, 1997) social cognitive theory which describes how an individual's perception of capacity to perform impacts levels of persistence, resilience, and stress.

Personal experience impacts perceptions of competence and thus efficacy for teaching (Bandura, 1986; Goddard et al., 2000). EFT perceptions are context and task specific based on an analysis of one's personal strengths and weaknesses related to a particular situation (Bandura, 1986, 1997; Buss, 2010; Goddard et al., 2000; Ross et al., 1996; Tschannen-Moran et al., 1998). These contexts, according to Bandura's theory of triadic reciprocal determinism, are in turn influenced by the interaction of behavior (instructional decisions), personal factors (including knowledge and beliefs), and environmental or contextual factors (Bandura, 1986; Pajares, 1996). Therefore, the school community in which an individual is operating can have a strong influence on the EFT beliefs of an individual, and the group as a whole (Figure 1.1).

Collective Efficacy for Teaching

One powerful construct that varies between schools (Goddard et al., 2000) and that has been shown to be more predictive of student achievement than even SES or ethnicity (Bandura, 1997; Goddard et al., 2000; Hoy, Sweetland, & Smith, 2002; Tschannen-Moran & Barr, 2004), is collective efficacy for teaching. Collective efficacy is defined as "more than the sum of individual attributes" (Bandura, 1997, p. 477), being shared beliefs about the groups' ability to work together to complete a needed course of action and have a positive effect on student outcomes (Bandura, 1997; Goddard et al., 2000; Goddard, Logerfo, & Hoy., 2004; Moolenaar et al., 2012). It is a social construct related to a schools' developed beliefs about student ability, teacher ability, and the ability of the administration to create an environment conducive to overcoming influences such as SES and prior achievement. (Bandura, 1993; Pajares, 1996).

Like individual efficacy, more positive collective efficacy perceptions are related to more effort (Moolenaar et al., 2012) and a focus on the purposive actions needed to achieve organizational goals, creating a normative environment that in turn influences teaching behaviors (Goddard et al., 2000; Figure 1.1). Based on the social cognitive theory of behavior change and triadic reciprocal causality, it has been found that when a group has positive perceptions of collective efficacy, these perceptions are apt to get stronger (Bandura, 1997; Goddard et al., 2000; Putnam, Heaton, Prawat, & Remillard, 1992). However, being a "relatively stable property that requires substantial effort to change" (Bandura, 1997, p. 10), negative perceptions of collective efficacy are difficult to change as well. The organizational environment, including contextual factors and professional support networks, can be instrumental in the development of positive collective efficacy perceptions (Figure 1.1), in that advice-seeking, advice-giving, and observing the successful experiences of others promote positive collective and individual efficacy for teaching beliefs. (Goddard et al., 2004; Moolenaar et al., 2012).

Sources of Efficacy for Teaching

Historically teachers in the U.S. have maintained control over curriculum implementation; however, increased accountability brought on by high-stakes testing has removed this level of autonomy and left teachers feeling discouraged and disempowered (Valli & Buese, 2007), in other words less self-efficacious. Further, those teaching the neediest students tend to work in the most restrictive environments with limited freedom and autonomy (Darling-Hammond, 1997; Green, 2014). For elementary mathematics educators, this is especially problematic because elementary teachers' EFT has been found to be lower for mathematics and science than other subject areas (Buss, 2010).

Bandura (1986, 1997) identified three major sources of individual efficacy:

- mastery experiences, both successes and failures, that are related to persistence,
- vicarious experiences, or watching others, which build group cohesion and persistence, and
- emotional arousal or affective states, which Goddard and colleagues (2000) suggest determine how challenges are interpreted.

These three types of support also relate to forming and functioning within learning communities as they provide "help in doing the work of teaching [and] help in reaching the teachers' goals of reaching the students" resulting in more positive individual efficacy perceptions (Shaughnessy, 2004, p. 164).

The Impact of EFT on Instruction and Student Achievement

Teachers who lack confidence are less apt to enact change and/or implement conceptually based methodology in their classrooms, therefore efficacy is one of the most influential teacher characteristics related to student success (Smith et al., 2005; Swafford et al., 1997; Valli & Buese, 2007; Figure 1.1). Goddard et al. (2000) found that collective MEFT can predict student achievement and can offset the impact of SES. Results from their collective efficacy survey of 452 elementary teachers from 49 schools in a large urban district in the Midwestern U.S., found that a one-unit increase in MEFT resulted in an 8.62-point gain in student mathematics achievement. They concluded that collective MEFT was an intervening variable between professional support networks and student mathematics achievement (Figure 1.1). Moolenaar et al. (2012) supported this finding with their qualitative study of the collaboration networks and collective EFT beliefs of 775 teachers in 53 urban and rural elementary schools in the Netherlands, showing both network density, defined as the number of existing social ties in relation to the number of possible social ties, and network centralization, defined as the number of individuals controlling the flow of resources, were both positively related to increased collective EFT and student achievement in language arts and mathematics.

Efficacy for teaching and job satisfaction are affective processes that impact choices and courses of action including effort, perseverance, resiliency, and emotional reactions (Daly et al., 2009; Shaughnessy, 2004), which in turn determine how lessons are constructed and implemented (Putnam et al., 1992). Positive EFT perceptions lead to more risk taking, viewing student errors as learning opportunities as opposed to learning barriers, displaying better instructional management, using more differentiation, maintaining continuous goals for student learning, spending more time planning and organizing instruction, and showing more commitment to teaching in general (Buss, 2010, Goddard et al., 2000; Hines, 2008).

Contextual Factors

Personal factors such as effort, resiliency, and risk taking, characteristics of individuals with positive EFT perceptions associated with more effective teaching and more positive student outcomes, are influenced by the organizational context in which a teacher is situated (Figure 1.1). "Scaling up instructional improvement efforts remains one of the central challenges facing urban school systems" (Coburn et al., 2012, p. 137). This struggle is magnified by a lack of understanding of how policies and other "bureaucratic mechanisms" influence the development of professional support networks embedded within the larger institutional organization (Coburn et al., 2013, p. 312).

Looking to help fill this research gap, Cobb and Jackson (2015) and Coburn and Russell (2008) used backward mapping approaches beginning with individual teachers to disseminate instructional leadership at an organizational level looking to “identify relevant aspects of the school contexts in which teachers work and in which they modify, adjust, and perhaps reorganize their instructional practices” (Cobb & Jackson, 2015, p. 1032). Among contextual factors hypothesized to most influence the task of teaching students are "abilities and motivations of students, availability of instructional materials, presence of community resources and constraints, and the appropriateness of a school’s physical facilities" (Goddard et al., 2000, p. 9). These are the same environmental and contextual factors found to impact teacher EFT as well (Pajares, 1996).

When examining the process of supporting teacher learning in several large urban districts in the U.S., Cobb and Jackson (2015) found that "specific aspects of school and system contexts...are influenced by the organization of the education system" and that instructional change will not be "sustained unless underlying pedagogical principles become institutionalized in school and system policies and routines" as part of the school’s culture (p. 1034). The changing priorities, limited resources, and competing demands that characterize many districts in the U.S., especially urban areas like Libertyville, make this sustainability difficult (Berends, Goldring, Stein, & Cravens, 2002; Hargreaves & Fink, 2000; Mac Iver, Ruby, Balfanz, & Byrnes, 2003).

Physical, Social, and Human Capital

Social capital theory posits that when working to engage in and sustain purposive action, individuals within an organization draw upon three types of capital: (a) human capital, including knowledge, skills, and dispositions; (b) physical capital, including staffing, time, money, and materials; and (c) social capital, including relationship strength, norms, and trust (Daly et al., 2009; Hasselbrink, 2014; Spillane & Thompson,1997). It is the interaction of human capital with the social capital available within professional relationships that ultimately determines whether physical capital supports or impedes sustainable professional growth and instructional transformation (Figure 1.1). It is through professional support networks that organizational resources, including mentoring, professional development, curricular materials, assessment instruments, personnel, computers, physical space, and schedules, are accessed, borrowed, and leveraged (Daly et al., 2009; Shulman & Shulman, 2004).

The availability of instructional materials and the appropriateness of physical facilities impact teachers' perceptions of the task of teaching students, which in turn impacts their perceived EFT. A strong correlation between school level resources and EFT has not consistently been found in studies. Shaughnessy (2004) believes this is because EFT is an individual teacher characteristic that is situation specific and therefore may be less affected by organizational level differences.

Policy Initiatives

Organizational policies are a contextual factor that encompass all other aspects of school systems (Shulman & Shulman, 2004). In most districts, teachers are routinely required to implement multiple programs, curriculum, assessments, and other mandates aimed at increasing achievement. These mandates are typically based on federal or state policies and/or district and school goals. Because many mandates stem from poor performance or persistent achievement gaps, this burden is especially prevalent in urban and other lower performing districts (Knapp, Bamburg, Ferguson, & Hill, 1998).

Converging demands. When faced with multiple mandates, three types of convergence occur: (a) mutual reinforcement, (b) interference, or (c) accumulation and overload (Hasselbrink, 2014). When accumulation and overload occur, multiple policy demands serve to expand the role and responsibilities of teachers and place new demands on their time and energy. Recent mandates connected to high stakes testing have left teachers feeling that potential collaborative planning and instructional time and energy is instead being devoted to collecting and analyzing high stakes summative assessment data, which teachers believe is primarily being used to make judgments about their teaching, not to help inform and support teaching and learning in their classrooms (Valli & Buese, 2007).

Supporting implementation. Policy documents are simply visions for reform, not plans for enactment. When organizations introduce mandates without helping teachers connect reform ideals to the needs of their own diverse learners, teachers are left feeling abandoned and with a diminished sense of autonomy and efficacy (Grant et al., 1996; Green, 2014). This is one reason large scale change necessitates a combination of top-down and bottom-up leadership that combines teacher expertise and current practice within the organizational capacity (Jaquith et al., 2011), to help teachers see how reform efforts fit in with existing government policies and district initiatives, thus measuring relative advantage (Cobb & Jackson, 2015; Cotner, Herrmann, Borman, Boydston, & LeFloch, 2005; Grant et al., 1996; Desimone et al., 2005; Valli & Buese, 2007). A clearer vision and deeper knowledge of the underlying theory behind initiatives allows teachers to adjust their existing practice as priorities change due to new policies or change in leadership (Coburn & Russell, 2008; Jaquith et al., 2011; Shulman & Sherin, 2004). A clear understanding by the school community of the underlying theory and purpose of initiatives also supports the spread or dispersal of reform practices, including MKT development, necessary for the reform to become embedded in system policies and routines (Cobb & Jackson, 2015), as well as implemented in classroom practice.

Professional Support Networks

School community includes a shared vision, shared commitment and support, a community of practice, and a shared knowledge base (Shulman & Shulman, 2004). Supportive professional learning contexts are nurturing environments where teachers and administrators collaborate to enact successful change processes. Teachers in these environments share a vision for student's potential achievement and feel supported in their own learning through a combination of ongoing and intensive learning opportunities centered on specific curriculum standards and directly linked to classroom teaching and learning (Jaquith et al., 2011; Shulman & Shulman, 2004).

Disseminating Knowledge and Ideas

These professional support networks most efficiently disseminate or diffuse information and knowledge when leadership responsibility has been distributed, and a supportive professional culture has been cultivated (Cobb & Jackson, 2015; Cotner et al., 2005; Frank et al., 2011; Valli & Buese, 2007). In order to cultivate change, district leaders must appreciate the amount of learning and work needed, so they will "allocate adequate resources over the long-term" and ensure coherence at a system level (Cobb & Jackson, 2015; p. 1033). Unfortunately, school leaders often lack the deep understanding of mathematics teaching and learning needed to support implementation of effective mathematics instruction and sustain teacher professional growth. Urban districts, in particular, have low levels of teacher and principal expertise around the implementation and identification of high-quality mathematics instruction (Cobb & Jackson, 2014). Making distributed leadership and ownership even more important to the development of a supportive professional climate.

In their mixed methods, exploratory case study of an underperforming, urban district in California, Daly et al. (2009) found that school principals are the primary conduits for the hierarchical flow of information, regardless of their approach to delivering this information to staff and their depth of knowledge and understanding of the reform. They also found that grade level teams were the main unit of enactment as this was where understanding of reform was co-constructed. As a result, Daly and colleagues determined that when interactions focused on teaching and learning and refining instructional practice, professional support networks were more densely connected and members had more autonomy at their grade level meetings. This led to “more interactive and collaborative lesson and assessment planning, more mutual trust, and more depth of engagement” (Daly et al., 2009, p. 378), factors that lead to more teaching knowledge development and increased individual and collective EFT (Figure 1.1).

Shared Responsibility for Student Achievement

Social network research looks at reforms through the lens of these professional support networks, both within and between schools, and their influence on the overall functioning of the organization (Francis, 2009; Moolenaar et al., 2012). Because positive collective EFT perceptions within these networks results in "acceptance of challenging goals, strong organizational effort, and persistence" (Goddard, et al., 2000, p. 10), collaboration within professional support networks indirectly influences student achievement through changes in "feelings of equally shared responsibility for positive outcomes, alignment of expectations for students, increased feelings of effectiveness, and raised sense of efficacy" (Moolenaar et al., 2012, p. 251), in other words more positive collective EFT perceptions (Figure 1.1).

Professional communities impact policy implementation and change through trust, expertise, and negotiation of meaning. However, little is known about the impact of policies on social interactions or networks and of those relationships in public schools. Looking to fill this gap, Coburn and Russell (2008) conducted an exploratory comparative case study of selected low SES, high minority urban elementary schools in two U.S. districts to identify district policy features that most influence professional support networks in schools. Using teachers' support networks as their unit of analysis, they examined the degree of span across organizational structures including tie strength (frequency and intimacy of relationships), trust, expertise (participation in training), and content of interaction (depth and congruence with reform). They found that professional support networks "provide opportunities for social capital transactions, provide access to information and expertise to support learning, and foster the depth of interaction that may be necessary for teachers to grapple with new approaches in ways that help them to question their assumptions and reconfigure their instructional practice over time" (p. 223).

Looking more closely at the content of interactions, as opposed to just the quantity or frequency, Moolenaar et al. (2012) identified two different types of professional networks in schools: instrumental networks and expressive networks. Instrumental networks support the exchange of work related information, knowledge, and materials. While expressive networks offer social support and friendship. They found that more densely connected networks of both types resulted in more collegial trust, increased EFT, and stronger motivation to engage in ongoing professional growth (Figure 1.1).

Professional Support Networks and Sustainability

Looking to deepen understanding of when, why, and how teachers' social relations contribute to sustainability, Coburn and colleagues (2012) conducted a three-year longitudinal study of a representational sample of elementary teachers in the U.S., using social network analysis approach, to investigate the relationship between professional support networks and sustainability through qualitative comparative analysis. A key finding was that "social networks with combinations of strong ties, high-depth interaction, and high expertise enabled teachers to adjust instruction to new conditions while maintaining their core pedagogical approach" (p. 137). By shifting the focus from the individual to the professional support network itself, they were able to determine that professional support networks fostered sustainability by providing feedback, shared expertise, and frequent interaction.

Developing shared understanding. This need for social support was also described by Frank et al., (2011) in their proposed process for successful professional growth and change. This three-stage process involves: (1) learning basic information in a setting outside of the classroom (*focus*), (2) exploring and adapting the use of this new knowledge within one's classroom (*fiddle*), and (3) refining this new knowledge by interacting with colleagues (*friends*). It is during this time with *friends* that perceptions are mediated by social persuasion and the successful experiences of others (Bandura, 1986; Ernest, 2010), allowing for conceptual reframing and adaptive application to novel situations (Ertmer & Newby, 1993).

A supportive learning environment that includes teacher proximity, regularly scheduled meetings, and strong leadership from teachers with expertise is important for knowledge and EFT development (Figure 1.1). Ma (2014) explains that opportunities to discuss the "interactions between 'what is it' and 'how to teach it' seem to provide the driving force for the growth of Chinese teachers' knowledge of school mathematics, while collegiality collects momentum for the process" (p. 138) as socially constructed meaning leads to new MKT development.

Network structures and knowledge exchanges. Looking to understand these social interactions more thoroughly, Daly et al.'s (2009) mixed methods case study of 196 teachers from five urban elementary schools near San Diego, CA used social network analysis to explore three questions: (a) to what extent do formal and informal professional support network structures within grade levels support or constrain the access and exchange of collaborative lesson planning, knowledge of reading comprehension, and reform-related effort recognition around district-wide change effort?; (b) how do teachers in different formal and informal positions in the network perceive the relational linkages through which the reform is diffused and enacted?; and (c) to what extent are professional network structures related to teachers' perceptions of collective action, EFT, and satisfaction with regard to the reform? Analysis of data from an online survey regarding network collaborative effort and EFT, as well as follow-up interview data regarding the role of social networks in knowledge flow and reform implementation, showed the importance of attending to relational linkages throughout the entire system as multiple "underlying social networks played a significant role in either supporting or constraining the ability of a grade level to understand and implement reform" (Daly et al., 2009, p. 381).

This study showed that more densely connected professional support networks had a more focused and collaborative learning orientation and perceived sense of autonomy, which led to higher levels of collective EFT, collegial trust, and satisfaction (Figure 1.1). These grade level "interaction patterns seemed to be influenced by the [school principal's] perception of his/her role in diffusing the reform" which in turn "defined how the reform was understood and ultimately enacted" (Daly et al., 2009, p. 382) at the grade level. Daly and colleagues concluded that both the frequency and focus of professional support network interactions impact teachers' sense of autonomy and empowerment, factors "critical to long-term sustainability" (p. 383) of reform initiatives, teacher professional growth, and ultimately student achievement.

Summary of the Literature Synthesis

Teaching mathematics is a complex endeavor requiring specialized knowledge of mathematics content, pedagogy, and student development (Hill, Rowan, & Ball, 2005; Ma, 2010; Shulman, 1986) and takes place within educational organizations that are equally complex, involving interactions of multiple individuals at multiple levels (Cobb & Jackson, 2015; Shulman & Shulman, 2004). Social cognitive theory (Bandura, 1986) emphasizes the importance of analyzing schools as social institutions by looking at individual knowledge, disposition, and behavior within the institution and the potential contextual factors that may promote or hinder high quality relationships within existing professional support networks.

Teacher quality impacts student achievement, both in the short and the long term. The amount and type of knowledge a teacher possesses in conjunction with their collective EFT perceptions is more impactful than contextual factors, including school resources and student demographics (Bandura, 1993; Goddard et al., 2000; Shulman & Shulman, 2004). To effectively teach mathematics, especially to struggling students, teachers need deep, flexible, and specialized knowledge, not just the common mathematics content knowledge taught in traditional mathematics courses and used by individuals in other professions (Hill, Rowan, & Ball, 2005; Ma, 2010). This complex knowledge is most effectively constructed through social interactions in supportive learning communities characterized by strong collective MEFT (Coburn & Russell, 2008; Coburn et al., 2012).

Chapter 2: Needs Assessment

To better understand the relationships between existing professional support networks, contextual factors, mathematics efficacy for teaching (MEFT), and levels of mathematical knowledge for teaching (MKT) a mixed method needs assessment was conducted. Knowing that "extended opportunities for teachers to learn, generous support from peers and mentors, and opportunities to practice, reflect, critique, and practice again" (Cohen & Hill, 2000, p. 307) are necessary components for teacher growth and instructional change, this study explored correlations between school-level, student, teacher, and contextual factors as well as the professional support networks (Coburn et al., 2012) of a subset of the elementary mathematics educators within the Libertyville Public School District.

Methodology

This study took an explanatory, mixed methods approach to examining the interaction of teachers' mathematics knowledge for teaching, teachers' mathematics efficacy for teaching, contextual factors including school and student characteristics, and professional support networks and their influence on student mathematics achievement (Creswell & Clark, 2011).

Participants

This study was conducted in the Libertyville Public School District (a pseudonym), an urban district in New England consisting of 41 schools, including 22 elementary schools. Of the approximately 24,000 students in the district, approximately 11,300 students attend the elementary schools, in kindergarten through fifth grade.

The students in Libertyville are a much more diverse group than is found in most districts in the state (Figure 2.1). Statewide about 40% of students identify as non-White or minority, whereas in Libertyville 93.6% of students fall into this category. Likewise, Libertyville has about four times as many students who qualify for ELL services (28%) as the state average and more than half of the students (60%) live in homes where English is not the primary language spoken. Libertyville also has a greater percentage of students from lower SES families. Statewide 47% of students qualify for free or reduced lunch compared to 85% in Libertyville (State Department of Education, 2015).

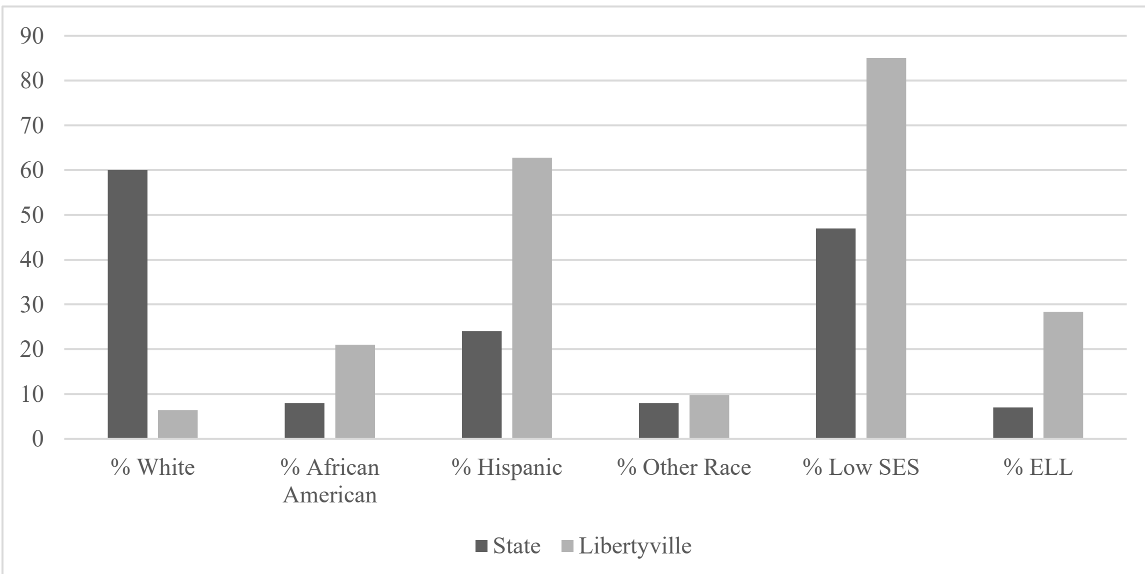


Figure 2.1. Student demographic data: State and Libertyville Public Schools.

This needs assessment focused on the third, fourth, and fifth grade classroom teachers, special educators, and school-based mathematics coaches from seven of the 22 elementary schools in the Libertyville Public School District. These educators comprised the implementation group of a federally funded Math Science Partnership (MSP) grant initiative focused on improving student outcomes in mathematics as well as raising the confidence and positive attitudes of teachers related to mathematics instruction (Tsankova, 2015). Teachers participated in this professional development partnership in conjunction with the state department of education and Freedom University (a pseudonym) from May 2015 through June

2016. The researcher, who works at Freedom University, had a prior relationship with the participants as a workshop and session facilitator throughout this initiative.

The seven schools were chosen to participate based on a willingness to commit to on-going involvement in this MSP initiative. These seven schools represented about half of the 15 elementary schools not involved in a separate district mathematics initiative focused on supporting English Language Learners (ELL; Tsankova, 2015). The schools involved in that ELL initiative were precluded from involvement in the MSP initiative.

In these seven schools, approximately 88 educators are involved in mathematics teaching and learning in grades three, four, and five, either as classroom teachers, special educators, or mathematics coaches. Following an inclusion model, the special educators co-teach alongside regular classroom teachers to support the individual education plans (IEP) of identified students. The mathematics coaches serve as instructional leaders within their designated schools, supporting the work of classroom teachers and special educators, as opposed to working directly with groups of students.

Of the original 88 educators eligible to participate in this PD initiative (Table 2.1), a total of 79 educators were actively involved in approximately 147 hours of professional development between August 2015 and April 2016. The professional development included a two-week institute during the summer of 2015 and eleven days of site-based PD during the 2015-2016 school year.

Table 2.1

Number of Educators Actively Involved in the MSP Professional Development by School

Cohort	School (pseudonyms)	Total Educators	Classroom Teachers (3-5)	Special Educators	Mathematics Coaches
A	Yellow	13	9	3	1
A	Green	13	12	0	1
A	Blue	8	4	3	1
A	Red	11	9	1	1
B	Purple	9	7	1	1
B	Brown	10	9	0	1
B	Orange	13	12	0	1
	Other	2	0	0	2
	Totals	**79**	**62**	**8**	**9**

Seventy-one percent (n = 56) of these 79 educators volunteered to participate in this needs assessment. This included, 17 third grade teachers, 13 fourth grade teachers, 13 fifth grade teachers, four special educators, and nine mathematics coaches. Three-quarters of the participants were experienced teachers having 12 or more years of experience. However, only 14.3% had 12 or more years of experience in their present position, with 65.5% having been in their present positions for less than seven years (Figure 2.2).

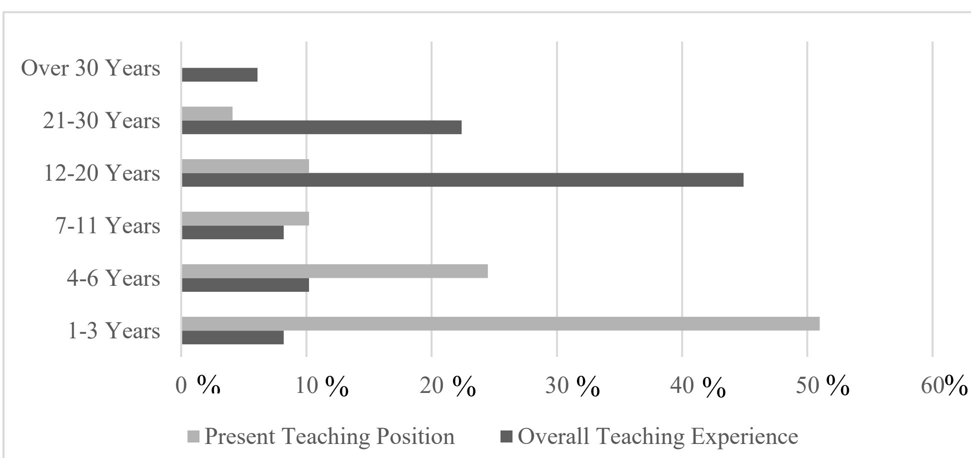


Figure 2.2. Teacher experience overall and in their present position.

Measures

To investigate the relationship between teacher characteristics, student characteristics, and contextual factors a mixed methods study was employed. Specifically, quantitative and qualitative data about MKT, individual MEFT, collective MEFT, professional support networks, and contextual factors including student characteristics and organizational policies gathered through surveys, questionnaires, and observations of professional development sessions were analyzed (Figure 2.3).

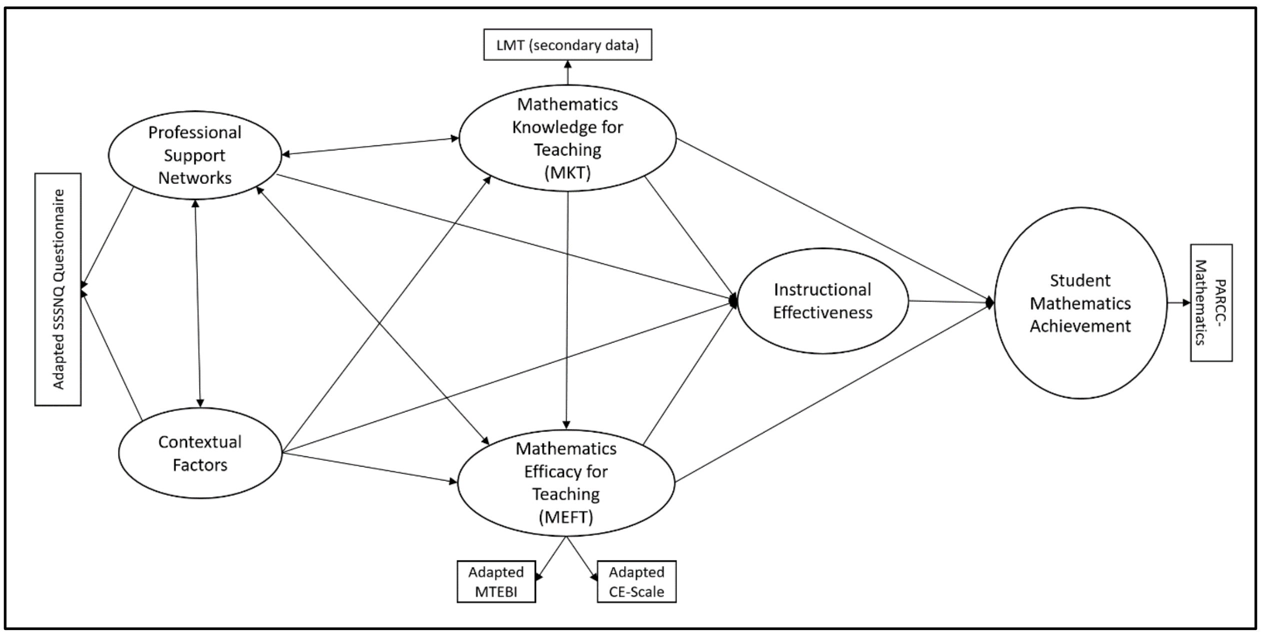


Figure 2.3. Conceptual framework showing measurement tools by construct.

Mathematics knowledge for teaching (MKT). A teacher's level of knowledge can be a significant predictor of student achievement gains, even more so than other variables including student backgrounds and time spent on mathematics instruction (Hill et al., 2005). MKT includes both specialized content knowledge (SCK), centered on the logic of the discipline, and pedagogical content knowledge (PCK), centered on students, instructional methods, and materials (Figure 1.2; Ball, 1990; Ball, Thames, & Phelps, 2008; Shulman, 1986; Speer, King, & Howell, 2014; Thames & Ball, 2010).

In this study, teacher's knowledge was examined as secondary data collected and analyzed as a pre- and post-test for the MSP mathematics initiative using the *Learning Mathematics for Teaching* survey (LMT). Development of this instrument was funded by the National Science Foundation and designed by the University of Michigan (http://sitemaker.umich.edu/lmt/about, 2008) to assess teachers' MKT (Tsankova, 2015). Ball and colleagues found the LMT items and forms reliable (a = .85) through multiple pilots with elementary teachers (www.umich.edu/~lmtweb). Instead of determining a specific level of competence for individual teachers, this assessment is designed to compare groups of teachers to national norms or to determine the effectiveness of professional development initiatives. MKT data from the interim and final MSP grant initiative reports were used as secondary data and disaggregated by both school and grade level, as well as by implementation and control groups (Tsankova, 2015; 2016).

The items on this assessment go beyond assessing basic mathematics content knowledge, focusing primarily on mathematical PCK. Items require teachers to make instructional decisions based on (a) student answers, for instance determining which student comment would provide a teacher with the best opportunity to discuss the comparison meaning of subtraction, (b) instructional materials, for instance determining which part of a multi-digit product is represented by the area shaded in gray in a decimal square, and (c) student perceptions, for instance deciding which visual diagram provides the best evidence that a student understands why multiplying the numerator and denominator by the same number results in obtaining an equivalent fraction. The teachers and coaches in this study completed three subscales of the assessment: number concepts and operations (grades K-6); functions, patterns, and algebra (grades K-6); and geometry (grades 3-8).

Additionally, field notes and written exit feedback from professional development sessions over the course of the MSP initiative were examined. Initial examination of these exit slips used a set of a priori codes based on Ball and colleagues' (2008) domains of MKT (Figure 1.2). Specifically, these written artifacts were initially examined for evidence of pedagogical content knowledge (PCK), specialized content knowledge (SCK), and common content knowledge (CCK). Statements such as, *I learned new strategies to teach word problems and make them easier for my students to comprehend*, were coded as PCK. Statements such as, *thinking about the numerator as an adjective and the denominator as a noun helped clarify my understanding of fractions,* were coded as SCK. And statements such as, *I had never realized that the x-axis needed to be the independent variable and the y-axis the dependent variable*, were coded as CCK. These written artifacts were then re-examined based on emerging themes, including development of personal mathematics knowledge, modification of pedagogical practices, and application to student learning to create a clearer picture of these educators' developing MKT (Ball et al., 2008; Ma, 2010; Shulman, 1986).

Mathematics efficacy for teaching (MEFT). Efficacy for teaching, defined as teachers' beliefs, dispositions, and feelings of adequacy regarding their own knowledge and preparedness to meet curricular goals and effectively support student learning (Bandura, 1997; Buss, 2010; Goddard et al., 2000; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998), is a strong predictor of behavior. MEFT is comprised of beliefs related to individual capacity as well as collective capacity to complete both the task of teaching mathematics effectively, or competence, and to impact student mathematics learning, or outcome expectancy (Bandura, 1986, 1997).

A two section MEFT survey looking at individual and collective efficacy perceptions, with subscales for both competence and outcome expectancy, assessed the multiple aspects of this construct (Appendix A). The instrument was developed using items related to individual MEFT from the Mathematics Teaching Efficacy Beliefs Instrument or MTEBI (Enochs, Smith, & Huinker, 2000) and collective MEFT from the Collective Efficacy for Teaching Scale or CE-Scale (Goddard et al., 2000). Previous studies found both instruments (MTEBI: a = .88; CE-Scale: a = .96) reliable with both practicing and pre-service teachers (Enochs et al., 2000; Goddard et al., 2000). Items were drawn from both the competence and outcome expectancy subscales for both surveys.

Efficacy beliefs are context and task specific based on an analysis of one's personal strengths and weaknesses related to a particular situation (Bandura, 1986, 1997; Buss, 2010; Goddard et al., 2000; Ross et al., 1996; Tschannen-Moran et al., 1998), thus domain specific measures are more predictive than omnibus measures which are decontextualized (Bandura, 1986; Pajares, 1996). In line with this, original items on the CE-Scale were adapted to focus specifically on mathematics instruction by changing generic statements like *teachers here are confident they will be able to motivate their students* to mathematics specific statements like *teachers here are confident they will be able to motivate their students* *<u>in mathematics</u>*. The original MTEBI scale was established for prospective teachers and thus many items are phrased in the future tense. Because the participants in this study were all practicing teachers, some items were rephrased to the present tense. For example, an item that originally read *I <u>will not be</u> very effective in monitoring mathematics activities* became *I <u>am not</u> very effective in monitoring mathematics activities*.

Bandura (1986) explains that when assessing efficacy, "scales that use only a few steps should be avoided because they are less sensitive and less reliable. People usually avoid the extreme positions so a scale with only a few steps may, in actual use, shrink to one or two points." (p. 312). Based on this insight, participants responded to the items using a nine-point Likert scale that ranged from strongly disagree (1) to strongly agree (9) for both the CE-Scale (originally a six-point Likert scale) and the MTEBI (originally a five-point Likert scale).

In recognition of the limited time teachers have and the large amount of surveys regularly administered in this district, only some of the items from each scale were included in this study (CTE: 11 of 22; MTEBI: 15 of 21). Items eliminated either duplicated other items, for instance *I teach mathematics ineffectively* and *I know how to teach mathematics effectively* or were related to factors not being examined in this study, such as *Drug and alcohol abuse in the community make learning difficult for students here*. Cronbach's alphas for individual MEFT ($\alpha = 0.86$) and collective MEFT ($\alpha = 0.85$) show these changes did not disrupt internal consistency (Connelly, 2011).

Both scales included negatively worded statements such as, *Teachers at this school don't have the skills needed to produce meaningful student learning in mathematics*, and positively worded statements, such as *I know how to teach mathematics concepts effectively*. This balance was maintained in the modified surveys. Negatively worded items were reverse coded during analysis.

In addition to the efficacy surveys, field notes and written exit feedback from professional development sessions were examined and coded using a priori codes. During the first phase, these written artifacts were coded for indicators of both positive MEFT perceptions, for example *I'm no longer afraid to let students fail in their attempts at learning because I know*

I can support them through the process, and negative MEFT perceptions, for example *I'm afraid that since my understanding is still fragile I won't be able to use it on my own.* Then these written artifacts were reexamined using four codes based on the different aspects of efficacy for teaching explored through this study's MEFT survey. These four codes were: individual MEFT, collective MEFT, outcome expectancy, and individual competence (Bandura, 1986; Enochs et al., 2000; Goddard et al., 2000). Findings from this qualitative analysis were then connected to quantitative data from the MEFT surveys to create a richer picture of the existing context (Creswell & Plano Clark, 2011).

Contextual factors. Analyzing schools as social institutions allows for strategic examination of the contextual factors, such as the "availability of instructional materials, presence of community resources and constraints, and appropriateness of a school's physical facilities" (Goddard et al., 2000, p. 9), as well as professional support networks (Coburn & Russell, 2008; Coburn et al., 2013; Moolenaar et al., 2012) that promote and hinder the professional growth, effective mathematics instruction, (Cobb & Jackson, 2015; Francis, 2009) and students' mathematics achievement. This study defines these contextual factors as a combination of formal, linked structures and organizational elements that shape practice. These include building and curricular infrastructures, the professional learning context, policies, and professional support networks (Daly et al., 2009; Goddard et al., 2000; Hasselbrink, 2014; Shulman & Shulman, 2004; Spillane & Thompson,1997).

Information related to contextual factors was gathered, (a) as secondary data from MSP evaluation reports (Tsankova, 2015, 2016), (b) from questionnaires completed by school-based mathematics coaches, principals, and district mathematics instructional school support liaisons (MISSLs; Appendices C, D, and E) related to personnel, scheduling, budgets, policies, mathematics initiatives, and curricular materials, and (c) from field notes and written feedback from PD sessions. Field notes and PD session feedback were examined and coded for statements related to contextual factors including: resources, such as *it is really hard to implement these strategies when we don't have the manipulatives and other materials at our schools,* and policies, such as *why did we switch textbooks*. This qualitative data analysis was connected to quantitative questionnaire data (Appendices C, D, and E) to examine the influence of contextual factors on teacher MEFT, professional support networks, and student mathematics achievement (Figure 1.1).

Professional support networks. It is known that underlying professional support networks can either promote or impede reform efforts and teacher knowledge growth (Coburn & Russell, 2008; Daly et al., 2009), but there is a gap in research related to an examination of "the relational linkages through which reform flows" (Daly et al., 2009, p. 385), especially the informal professional support networks between grade levels, schools, and support staff. In order to develop an understanding of some of these *relational linkages* through social network theory, questions were drawn and adapted from the Research, Evaluation, and Technical Assistance (RETA): School Staff Social Network Questionnaire or SSSNQ (Spillane, Peterson, Sherin, Fisher, & Konstantopoulos, 2012), a survey developed to describe and analyze leadership practices for middle school mathematics instruction. A questionnaire developed using SSSNQ questions (Appendix B) asked teachers to identify the characteristics of individuals from whom they seek help or assistance related to mathematics instruction. Questions included their relationship to the individual, the type of advice that is sought from this individual, the frequency of these interactions, and the perceived influence of the advice on changing their practice.

One aspect changed from the original SSSNQ survey was that participants were not asked to reveal the name of individuals from whom they sought information, just their relationship to this person. This was done to help maintain anonymity as well as to better match the research purpose of identifying the characteristics of the relationships as opposed to the specific individuals. Mathematics coaches were also asked to identify their primary sources of information and advice related to both supporting mathematics instruction at their schools as well as providing instructional coaching to individual teachers (Appendix C).

Data Collection

Data for this study were collected in four ways. Existing data from the MSP mathematics initiative reports (Tsankova, 2015) were used as secondary data, notes from direct observations by the researcher at professional development sessions and collected teacher exit slips from those sessions were coded and used as qualitative data, and quantitative data were collected through surveys and questionnaires. This mixed methods approach helped to create a more complete picture of the current problem and context (Creswell & Clark, 2011).

Teacher knowledge. All classroom teachers, special educators, and mathematics coaches who work with third, fourth, and fifth grade students, at the fifteen district schools not involved in a district ELL mathematics initiative were recruited to complete the LMT assessment using the online Teacher Knowledge Assessment System (TKAS) platform as a pre-test prior to the start of the MSP professional development sessions during the spring of 2015 and again as a post-test in May 2016 after the MSP initiative was completed. Seventy-five percent of teachers from the implementation group schools completed the pre-test (Tsankova, 2015) and 52 % completed the post-test (Tsankova, 2016). For this needs assessment, LMT z-scores based on national norms and disaggregated by both school and grade level were collected as secondary data from the interim and final evaluation reports for the MSP initiative (Tsankova, 2015, 2016).

Mathematics efficacy for teaching (MEFT). All teachers and mathematics coaches who were actively involved in the MSP initiative (Table 2.1) were recruited to complete a two-part survey related to MEFT, both individual and collective. Originally, participant recruitment was planned to be conducted in person by the researcher during the final PD session for each of the six cohorts (two per grade level), thus a paper and pencil survey was developed. However, a delay in approval from the district pushed back the start of the study until after some of the final cohort sessions had already taken place, so in-person collection was not possible for three cohorts. The researcher still recruited individuals from the two grade three cohorts (A and B) and one of the grade five cohorts (A) in person during their final PD sessions. Individuals at these sessions completed the surveys during a break and placed the completed forms in an envelope identified by their respective schools. The mathematics coaches volunteered to distribute and collect surveys for the remaining cohorts of teachers (grade four cohorts A and B and grade five cohort B) at their respective schools, either individually or during a grade level meeting. The researcher then collected envelopes containing completed surveys from each school.

In all, 71% of the 66 recruited teachers completed this survey (Table 2.2). Participation rates were lower for grade 4 cohort A and B and grade 5 cohort B, likely because recruitment was not done by the researcher when all participants were present at a single meeting, but instead was done by their school-based mathematics coaches within their daily schedule when follow-up was more difficult. The data collection period also coincided with both a school vacation week and state testing which also may have impacted participation rates.

This survey was completed anonymously but some personal data was collected, including respondents' school, grade level, and years of teaching experience. These personal data were used to disaggregate data during analysis.

Table 2.2

Percent of Classroom Teacher Participation by Grade Level Cohort

School		Third	Fourth	Fifth	Overall
		Grade			
Cohort A	Yellow (*n*=10)	100	66	100	90
	Green (*n*=11)	100	100	100	100
	Blue (*n*=6)	100	100	50	83
	Red (*n*=9)	66	75	100	78
Cohort B	Purple (*n*=9)	50	50	66	56
	Brown (*n*=9)	25	0	50	22
	Orange (*n*=12)	40	25	33	33

Contextual factors. Contextual factors data were gathered from the seven participating school principals, two district elementary MISSLs, and school-based mathematics coaches through questionnaires that contained a combination of multiple choice and open-ended questions. The researcher administered a questionnaire (Appendix C) to fifteen of the twenty-two mathematics coaches in attendance at a monthly coaches' meeting. A district policy prohibiting data collection during the final 30 days of the school year eliminated the possibility of having the seven coaches not in attendance complete the questionnaire at a later date. The two MISSLs completed a questionnaire (Appendix D) during a meeting with the researcher. The principals from the seven implementation schools were initially emailed a questionnaire

(Appendix E). Only two of the principals returned their questionnaires, so a second attempt was made using Google Forms. This resulted in only three more questionnaires being returned, despite follow-up emails from both the MISSLs and the mathematics coaches from these schools. In total, five of the seven principals completed the questionnaire, a 71% response rate.

Professional support networks. Teachers were asked at the end of the MEFT survey (Appendix A) if they were interested in participating in the second phase of the research, requiring that they complete a questionnaire related to professional support networks. Individuals indicated their interest by providing their name and email address and/or phone number on a slip at the end of the MEFT survey. These notifications of interest in continuing in the study were subsequently removed from the document by the researcher so the original survey responses remained anonymous.

Participating teachers who volunteered (n = 22) were emailed the professional support network questionnaire directly using the introductory letter in Appendix F as the email text. After the initial email, only four teachers returned the surveys, so two additional emails were sent out, using blind carbon copy, with the surveys again attached thanking individuals for supporting the research and reminding them to complete the surveys. These additional attempts yielded six more responses for a total of eight participants. After consulting with the MISSLs, the survey was sent out again to the remaining volunteers using Google Forms. This resulted in an additional four surveys being returned, for a total of 12 participants, a response rate of only 55%. The collection window coincided with both a school vacation week and state testing, which may have impacted the response rate. A district policy prohibiting data collection during the final 30 days of the school year also precluded the option of waiting until after state testing was completed to collect the data.

Results

In an effort to determine which teacher, student, and contextual factors most impact teachers' MEFT perceptions, a descriptive statistical analysis and series of correlation analyses were employed. Specifically, the following questions were examined:

(a) What school level student and teacher factors influence MEFT perceptions?

(b) What school level student and teacher factors influence student proficiency?

(c) What type of relationship is there between individual MEFT and collective MEFT perceptions at the school level?

Additionally, qualitative analyses using a combination of a priori codes and emerging codes, as described earlier, were employed to determine:

(d) What types of support related to mathematics instruction do educators in Libertyville seek from individuals in different roles?

(e) What types of relationships do educators in Libertyville most value when seeking support related to mathematics instruction?

(f) What school and district contextual factors are viewed as influencing mathematics instruction?

School Level Factors and MEFT

Mathematics efficacy for teaching (MEFT) is influenced at the school level by both teacher characteristics, such as knowledge and experience (Dimopoulou, 2014; Goddard & Goddard, 2001; Hill, 2007), and student characteristics, such as prior achievement and demographics (Buss, 2010; Darling-Hammond, 1997). In contrast to existing empirical data, a correlational analysis of survey data for both individual and collective MEFT from Libertyville educators showed few of the expected correlations between student mathematics achievement and either teacher or student characteristics, even with the impact of the study's small sample size taken into account (Table 2.3).

Student characteristics and MEFT. The student characteristics examined include the percentage of students at a given school with either minority status, low SES, or ELL designations (Table 2.3). These three characteristics have been found to negatively correlate with teacher efficacy perceptions both in general (Darling-Hammond, 1997) and in mathematics specifically (Buss, 2010; Green, 2014), meaning schools with higher percentages of students within these categories tend to have teachers with more negative MEFT perceptions.

Correlational analysis revealed that as expected, the percentage of low SES students at a school was negatively correlated with the individual MEFT perceptions of educators at that school ($r = -0.52$, $p \leq .05$), meaning that teachers from schools with higher percentages of low SES students in Libertyville had lower individual MEFT perceptions (Figure 2.4). However, in contrast to extant findings, neither the percentage of ELL ($r = 0.38$, $p \leq .05$) nor minority ($r = -0.43$, $p \leq .05$) students at a school were strongly correlated with individual MEFT perceptions. An additional unanticipated result was that these student characteristics were only moderately correlated with the collective MEFT perceptions of educators at the school level (Table 2.3). Thus, assuming a linear relationship, these results seem to indicate that in these Libertyville elementary schools, teachers' MEFT perceptions at the school level are not strongly correlated with the characteristics of the student population, especially their perceptions of collective capacity.

Teacher characteristics and MEFT. Teacher experience is often used as a proxy measure for expertise and knowledge (Hill, 2007; Hill et al., 2005; Smith et al., 2005). Because teacher knowledge is positively correlated with EFT (Hill, 2007), it was anticipated that teachers

Table 2.3.

Correlational Analysis of Teacher [a] and Student Characteristics at the School Level [b]

	Teacher Individual MEFT	Teacher Collective MEFT	Teacher MKT	% of Student Proficiency	% of Minority Students	% of Low SES Students	% of ELL Students
Teacher Individual MEFT	1.00						
Teacher Collective MEFT	-0.02	1.00					
Teacher MKT	-0.17	0.05	1.00				
% of Student Proficiency	-0.22	0.43	0.28	1.00			
% of Minority Students	-0.43	0.33	-0.29	**0.64**	1.00		
% of Low SES Students	**-0.52**	0.38	**0.65**	**0.68**	0.49	1.00	
% of ELL Students	0.38	0.33	0.18	-0.51	-0.41	-0.03	1.00
Overall Teaching Experience	0.39	0.37	**-0.56**	-0.22	-0.25	-0.67	0.09
Experience in Present Position	**-0.54**	0.25	-0.45	0.36	**0.50**	-0.04	**-0.67**

Note. Correlations listed are Pearson r values. r values ≥ .5 are in boldface and indicate a statistically significant correlation. MEFT = mathematics efficacy for teaching; MKT = mathematics knowledge for teaching; ELL = English language learners.

[a] $n = 56$. [b] $n = 7$

$p \leq .05$

with more experience, both overall and in present positions would have more positive perceptions of both individual and collective MEFT. In contrast to expected results (Dimopoulou, 2014; Goddard & Goddard, 2001), a correlational analysis at the school level, revealed the amount of experience educators had in their present positions, defined by both grade level and school, had a negative correlation (r = - 0.54, $p \leq .05$) with the individual MEFT perceptions of educators at that school (Figure 2.4), meaning that educators with less experience in their present positions had more positive individual MEFT perceptions. Additionally, neither measure of teacher experience was strongly correlated with collective MEFT perceptions at the school level with only a moderately positive correlation with overall teaching experience (r = .37, $p \leq .05$; Table 2.3). These results may indicate the presence of unanticipated confounding factors.

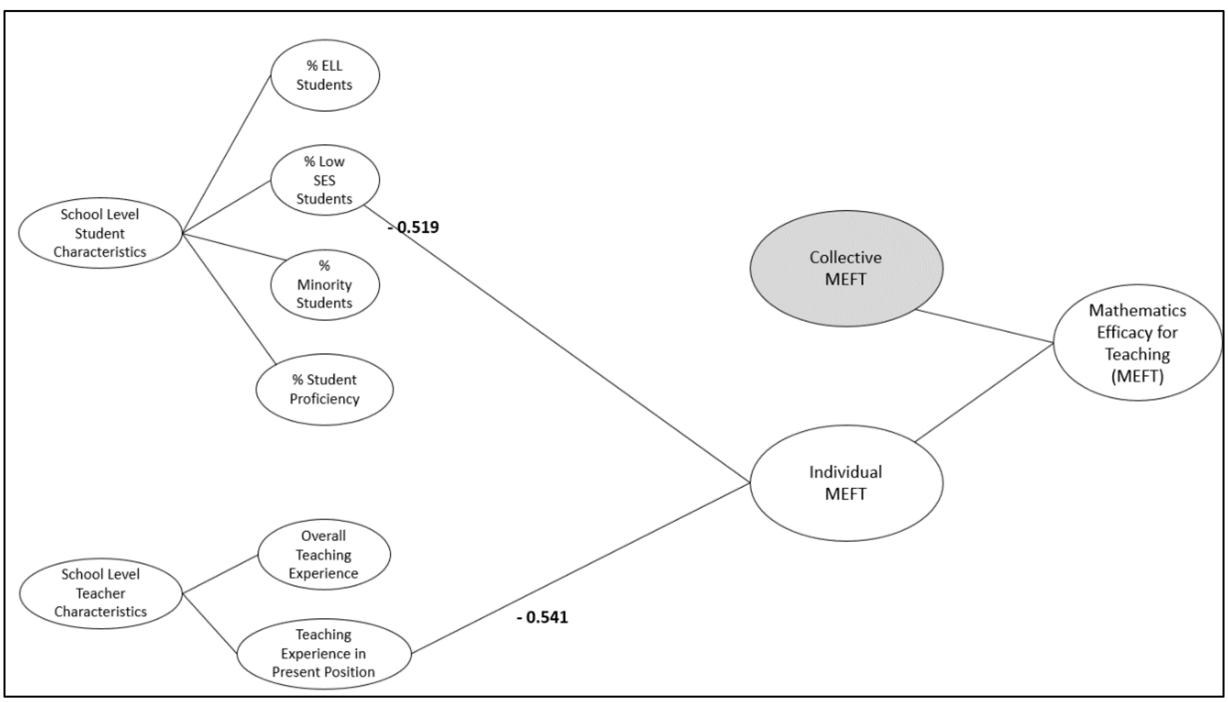


Figure 2.4. Concept map of school level factors with significant correlations (r > .5, $p \leq .05$) to MEFT with the school as the unit of analysis.

One possible explanation for these unexpected findings is that there was a negative correlation between MKT scores and teacher experience both overall ($r = -0.56$, $p \leq .05$) and present positions ($r = -0.45$, $p \leq .05$; Table 2.3). Leana and Pil (2006) also found that teacher experience did not predict students' mathematics achievement in their study of the effects of social capital on organizational performance in 88 urban, public schools in the U.S. They explained that because expectations around mathematics pedagogy have changed dramatically in the past few decades, "experience in teaching math does not necessarily impart the advantage one might expect" (p. 362), thus there may be an indirect relationship between teacher MKT and MEFT connected to this phenomenon.

School Level Factors and Student Mathematics Proficiency

Student mathematics achievement is influenced by instructional quality, which is mediated by teacher MKT (Ball, Thames, & Phelps, 2008; Hill, 2007; Smith et al., 2005), MEFT (Bandura, 1986; Pajares, 1996), professional support networks (Darling-Hammond, 2003; Moolenaar et al., 2012), and contextual factors (Cobb & Jackson, 2015; Figure 1.1). Demographic characteristics and student learning profiles, incorporated in this study's definition of contextual factors, also influence levels of student mathematics proficiency (Darling-Hammond, 1997). A correlational analysis was employed to examine the relationship between student demographic characteristics and student mathematics proficiency.

Student demographic characteristics and student mathematics proficiency. Based on existing research findings (Darling-Hammond, 1997; Okpala et al., 2000), it was anticipated that schools with higher percentages of low SES, minority, and ELL students would have lower levels of student proficiency in mathematics. A moderate correlation was found between all three of these student characteristics and student mathematics proficiency, however not all correlations were negative as anticipated (Table 2.3). As expected, there was a moderate negative correlation between the percentage of ELL students at a school and student mathematics proficiency ($r = -0.52$, $p \leq .05$), however both the percentage of low SES ($r = 0.68$, $p \leq .05$) and minority ($r = 0.64$, $p \leq .05$) students had a moderate positive correlation with student proficiency (Figure 2.5). Meaning that although schools with a higher percentage of students qualifying for ELL services had lower levels of student mathematics proficiency, schools with higher percentages of low SES and minority students actually had higher percentages of students who were proficient in mathematics.

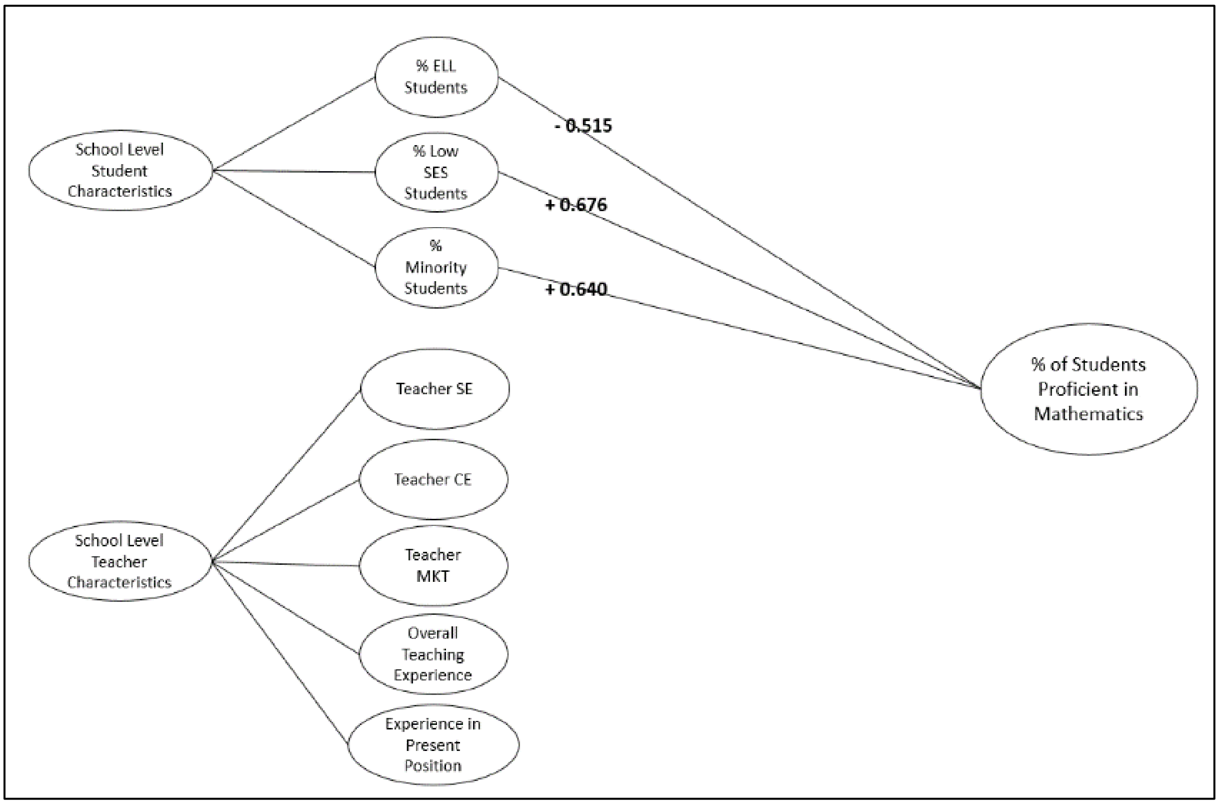


Figure 2.5. Concept map of school level factors with significant correlations ($r > .5$, $p \leq .05$) to student mathematics proficiency with the school as the unit of analysis.

An examination of other school level factors revealed one potential explanation for this relationship. There is a moderate positive correlation between teacher MKT and the percentage of low SES students at a school ($r = 0.65$, $p \leq .05$; Table 2.3). So, as has been found in other studies (Chetty, Friedman, & Rockoff, 2014; Darling-Hammond, 1997; Downey et al., 2004; Gamoran & Long, 2006; Hanushek & Rivkin, 2010; Koppich, 2000), strong teacher MKT at these schools may be indirectly impacting student achievement, as a result of higher quality instruction even though only a weak positive correlation was found ($r = .28$; $p \leq .05$; Table 2.3).

Teacher characteristics and student mathematics proficiency. It was anticipated that teacher MEFT, MKT, and experience would all be positively correlated with student proficiency. Teacher knowledge, measured both directly as well as using proxy measures such as experience, has been shown to positively influence EFT perceptions (Chetty, Friedman, & Rockoff, 2014; Cobb & Jackson, 2015; Darling-Hammond, 1997; Downey et al., 2004; Hill, 2007). Existing research also shows a positive correlation between both individual and collective EFT and student achievement (Smith et al., 2005; Swafford, Jones, & Thornton, 1997; Valli & Buese, 2007). Additionally, collective efficacy is a strong indicator for student achievement, even surmounting other external factors such as low SES and minority status in some studies (Goddard et al., 2000; Moolenaar et al., 2012). However, results from a correlational analysis at the school level, in this needs assessment context, revealed that none of these school level teacher characteristics were even moderately correlated with the students' mathematics proficiency (Table 2.3). This is a surprising result because teacher knowledge and efficacy have been repeatedly found to be mediating factors for instructional effectiveness and student achievement (Ball, Thames, & Phelps, 2008; Bandura, 1986; Green, 2014; Smith et al., 2005).

Anecdotal evidence from participants' written comments on open-ended exit slips from PD sessions suggest that teachers' MKT and MEFT changed as a result of the intensive MSP initiative. MKT related comments from the summer institute at the beginning of the MSP initiative (August 2015) focused mainly on specific strategies and models. For instance, teachers made comments such as, *I loved the living number line for fractions and will definitely use it in my classroom* and *I liked using the tape diagram to solve problems.* Comments from this early period such as, *what is the right vocabulary to use – borrow, regroup, exchange, decompose - I'm really confused* and *I wasn't aware that problems had different structures* also reflected basic knowledge gaps. In contrast, MKT related comments following PD sessions in March and April 2016, toward the end of the MSP initiative, focused more on the underlying structures of mathematics and developing student understanding. For instance, teachers wrote, *I'm putting much more emphasis on place value understanding across concepts so that students can develop flexibility with their strategies* and *it is important to make time for students to discuss their thinking and explain how they got their answers.* Comments also reflected teachers' growing awareness of the importance of MKT. When providing feedback at the end of the two-week summer institute (August 2015), one teacher wrote, *I learned that to teach well, teachers need to know content. I know I struggle with fractions. I have to work on it.* And a teacher at her final school year session (April 2016), referring to the use of conceptually based instructional strategies in her instruction stated, *I do it a lot, now that I know what to do.*

Individual and Collective MEFT Perceptions

Efficacy is comprised of perceptions of both individual and group competence related to successful completion of a given task or attainment of outcome expectancy in relation to external factors (Bandura, 1986). For mathematics efficacy for teaching (MEFT), this task would be teaching mathematics and supporting students' mathematics achievement. Although collective efficacy is defined as being more than the sum of the individuals' efficacy (Bandura, 1997), research, including studies specific to urban elementary teachers (Goddard & Goddard, 2001), consistently shows a positive relationship between individual and collective efficacy for teaching (Casanova & Azzi, 2015; Dimopoulou, 2014; Goddard & Goddard, 2001; Skaalvik & Skaalvik, 2007). Goddard and Goddard's (2001) study of elementary educators ($n = 452$) from a large urban district in the mid-western U.S., found that not only were these two aspects of efficacy for teaching (EFT) correlated, but that collective EFT perceptions predicted individual EFT perceptions, accounting for 75% of the variation among schools when considered together with other contextual factors such as minority concentration, prior student achievement, and proportion of low SES students. The moderate (Casanova & Azzi, 2015; Goddard & Goddard, 2001) to strong (Dimopoulou, 2014; Skaalvik & Skaalvik, 2007) correlations from previous studies, indicate the near zero correlation ($r = -0.02$; $p \leq .05$) between collective and individual MEFT found in this study is unusual and does not appear to be explained by other school level teacher or student factors (Table 2.3).

Despite a lack of correlation (Table 2.3), this study's finding that perceptions of collective MEFT were lower than those of individual MEFT in all schools (Table 2.4) is consistent with prior research (Casanova & Azzi, 2015; Dimopoulou, 2014; Goddard & Goddard, 2001; Skaalvik & Skaalvik, 2007). Collective efficacy is situation specific and refers to individual future-oriented beliefs related to systemic ability (Bandura, 1997; Goddard et al., 2004; Moolenaar et al., 2012). These perceptions are influenced by the characteristics of professional support networks within an organization, including collegial trust and network density, or the number of social ties in relation to the number of possible ties (Lee et al., 2011; Moolenaar et al., 2012). Strong social ties and perceptions of collective capacity both develop over time as "patterns of interaction…increase trust and reinforce common expectations" (Bryk, Camburn, & Louis, 1999, p. 758) with the opposite effect occurring where turn-over is high (Bryk, et al., 1999; Spillane & Thompson, 1997).

Table 2.4.

Mean Comparisons for Individual and Collective MEFT at the School Level for All Educators.

School	Individual MEFT Mean (*SD*)	Collective MEFT Mean (*SD*)
Yellow (*n*=12)	6.74 (1.09)	5.50 (1.09)
Green (*n*=12)	6.98 (.90)	5.89 (1.14)
Blue (*n*=7)	7.45 (.49)	5.35 (.97)
Red (*n*=9)	7.20 (.93)	6.03 (1.38)
Purple (*n*=6)	6.88 (1.16)	5.12 (1.11)
Brown (*n*=3)	7.36 (.97)	5.27 (1.07)
Orange (*n*=5)	6.18 (.61)	5.53 (.44)
Total (n=56)	6.99 (.93)	5.58 (1.07)

Note. Responses based on a nine-point Likert scale ranging from strongly disagree (1) to strongly agree (9).

In these Libertyville schools, more than half of the teachers have only been in their present positions, at their present schools, for one to three years (Figure 2.2), indicating that one possible explanation for these more negative perceptions of collective MEFT may be a lack of strong ties and collegial trust (Coburn & Russell, 2008; Daly et al., 2009). Even though these individuals, 70% of whom have twelve or more years of overall teaching experience, have moderately high perceptions of their individual capacity, they may not have established relationships with grade and school team members and thus lack confidence in their collective capacity.

This may be especially true for the mathematics coaches. Seventy-eight percent of the coaches have twelve or more years of overall experience, but 67% of them only have one to three years of experience in their positions as instructional leaders at their schools. These individuals (*n* = 9) had highly positive individual MEFT perceptions (*M* = 7.57) but only moderately positive collective MEFT perceptions (*M* = 5.11; Table 2.5).

Table 2.5

Means Comparison for Individual and Collective MEFT for Teachers and Coaches

Position	Individual MEFT Mean (*SD*)	Collective MEFT Mean (*SD*)
Teacher (*n*=47)	6.88 (.92)	5.68 (1.10)
Coach (*n*=9)	7.57 (.83)	5.11 (.83)
Total (*n*=56)	6.99 (.93)	5.59 (1.07)

Note. Responses based on a nine-point Likert scale ranging from strongly disagree (1) to strongly agree (9).

Anecdotal evidence supports the assumption that this difference may be related to a lack of trust and connection to the teachers at their schools. One example is a comment written by one of the coaches in the margin of her CE-Scale explaining,

> My school is comprised of very split views on education and teacher responsibilities. I would say that there is a 60/40 split with 60% of staff who are dedicated to their craft and look for ways to improve their teaching abilities to meet the ever-changing needs of students. The other 40% are jaded for various reasons. They blame students and their

situations for why [students] fail. Their teaching practices resemble an old-fashioned approach which does not prove beneficial in today's learning styles. I don't know how I am supposed to support individuals with this type of attitude.

A second piece of anecdotal evidence was the observation that during PD sessions many of the coaches chose not to sit with the teachers with whom they work, but instead sat in a cluster at a separate table. Even with prompting from facilitators, it was difficult to engage the coaches in collaboration with classroom teachers. This was also addressed specifically in the fall MSP evaluation report which stated, "There were significant differences … in terms of experience and established relationships as instructional leaders with their teachers" many "coaches perceived their role in the summer PD as participants rather than facilitators. They preferred to sit together rather than with their teachers" (Tsankova, 2015, p. 44). Without strong ties to each other, as well as to the teachers at their individual schools, it will be difficult for these instructional leaders to effect change throughout the district (Coburn et al., 2013).

Professional Support Networks

The effectiveness of social networks within school districts to support professional and organizational growth is in part determined by tie strength (frequency and intimacy of relations) and network density (the number of existing social ties in relation to the number of possible social ties) within a given professional support network (Moolenaar et al., 2012). Teachers (*n*=12), coaches (*n*=15), principals (*n*=5), and the two district mathematics instructional school support liaisons (MISSLs) were all asked to provide information related to the mathematics professional support networks within the elementary schools in Libertyville.

When asked to choose what types of information or advice related to mathematics instruction they seek from other educators within the district from a list of five options

(Appendix B), teachers' most common responses were (a) that related to instructional approaches for teaching mathematics content (100%) and (b) strategies specifically aimed at assisting low-performing students (100%; Figure 2.6).

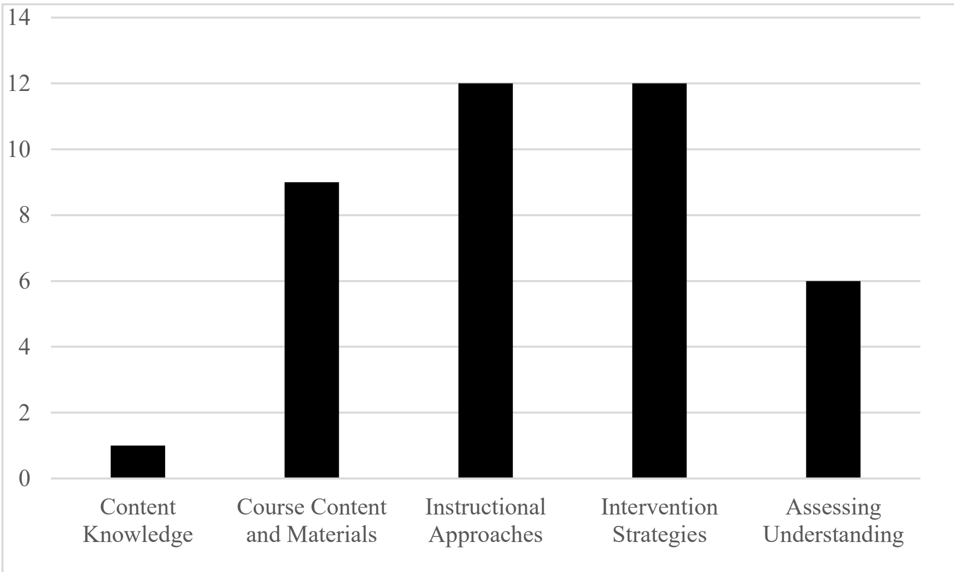


Figure 2.6. Number of teachers (*n*=12) seeking different types of information related to mathematics instruction from other district educators.

Interestingly, only one teacher mentioned seeking information related to mathematics content knowledge from other district educators, even though teacher knowledge was identified by all of the coaches, principals, and district MISSLs as a major impediment to effective mathematics instruction and student achievement. Additionally, supporting the development of teachers' MKT through instructional coaching is a specific component of the coaches' job description and was identified as one of the important roles of the coaches by the district MISSLs, school principals, and the mathematics coaches themselves.

Teachers sought out professional advice from individuals in a variety of roles (Figure 2.7), however the greatest amount and variety of advice was sought from their school-based mathematics coach (75%) and grade level team members (75%; Figure 2.8). Although it is common for teachers to interact most frequently with grade level team members and subject leaders within their schools (Friedman, 2011), Daly et al. (2009) found that it is the "exchange of advice throughout the whole team, rather than the centralization of advice around central focal individuals" (p. 259) that "facilitate(s) collective action and the achievement of desired goals" (p. 252). Professional support networks spanning across multiple groups, expand access to skill sets and better support EFT development (Goddard et al., 2004; Daly et al., 2009).

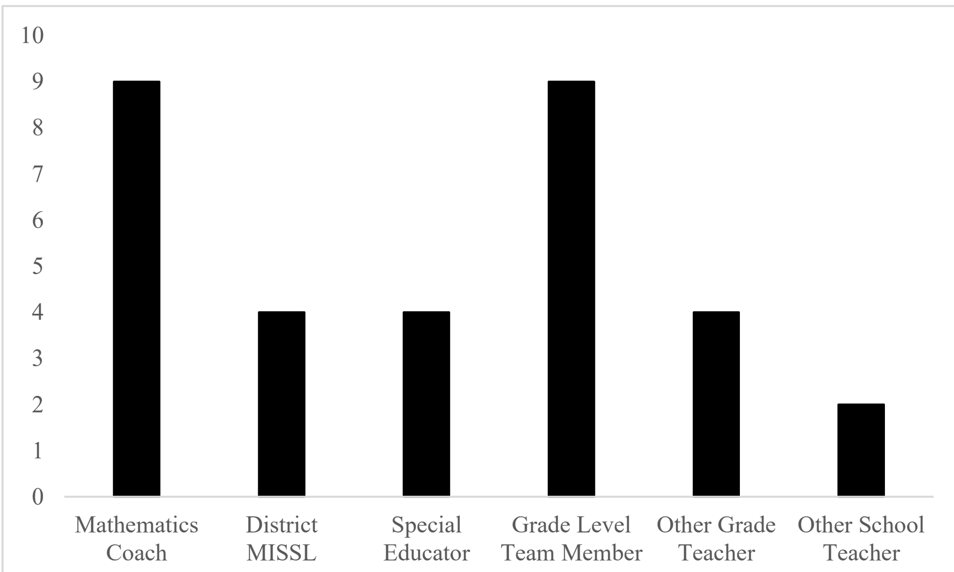


Figure 2.7. Number of teachers (*n*=12) seeking advice about mathematics instruction from district educators in different roles.

Even though supporting the mathematics teaching and learning work of the school-based mathematics coaches and school principals is a primary role of the district MISSLs, none of the principals identified the MISSLs as a source of information related to mathematics instruction and only 40% of the school mathematics coaches sought advice from the district MISSLs. Additionally, only 33% of teachers sought advice from the district MISSLs (Figure 2.7) and most only sought them out occasionally, either monthly or quarterly. Teachers did state highly valuing the advice ($M = 4.75$) they received from the MISSLs on a variety of topics.

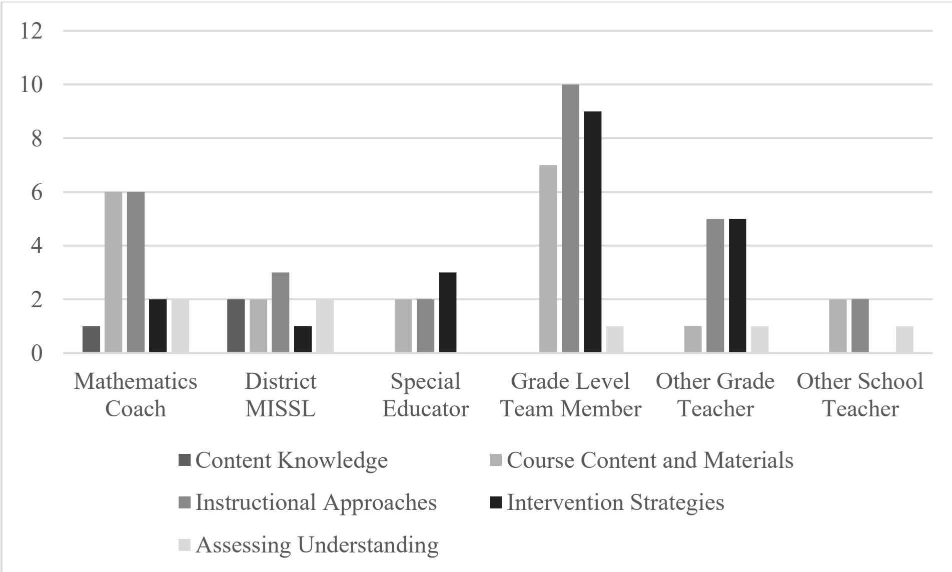


Figure 2.8. Number of teachers (*n*=12) seeking different types of advice from district educators in different roles.

These findings indicate that the MISSLs may be an underutilized resource within the district. This may be partially explained by recent turn-over in district administration. The district's Superintendent, Director of Curriculum and Instruction, Supervisor of K-12 Mathematics, and one of the district MISSLs had all been hired within the twelve months prior to the start of this study. Leadership change and accompanying shifts in policies and priorities may have a negative impact on teachers' collective MEFT perceptions and overall trust in those holding leadership positions (Cotner et al., 2005), an effect that can be mediated through shared leadership and strong professional support networks (Kennedy & Smith, 2013).

The present administration has established the development of a cohesive, district wide team for mathematics instruction as a priority. This includes shifting the focus of the mathematics coaches from school-based isolation to seeing themselves as part of a district team which assumes accountability for each other and the district as a whole, not just for their individual schools. As part of this work, the district MISSLs will be freed up from some of their administrative responsibilities so they can be in schools more regularly in hopes that their consistent presence will enable more effective identification of needs and opportunities for support, as well as support the development of a more collaborative work environment.

Contextual Factors and Mathematics Instruction

Contextual factors, including building and curricular infrastructures, indirectly influence student achievement and instructional effectiveness through their influence on teacher efficacy and knowledge development (Figure 1.1; Goddard et al., 2000). When asked what they perceived as impediments to instructional effectiveness in mathematics, in addition to teacher MKT, district MISSLs, school principals, and mathematics coaches all identified district constraints such as policies, materials, instructional resources, and time for both instruction and collaborative planning.

Access to resources. Acknowledgement of these factors was also evident in comments written in the margins of the MEFT surveys and on written exit slip feedback following MSP grant PD sessions. Following one session a teacher wrote, *we keep talking about how important it is for kids to work with models and manipulatives, but I don't know how I'm supposed to do that when we only have one set of them for the whole school.* This lack of materials was also apparent in the following observation made by the researcher when watching a grade three lesson on fractions,

> During Ms. F.'s (a pseudonym) fraction lesson she worked to support struggling students using fraction tiles. She only had one set of tiles that could be laid out in a linear fashion and this set was incomplete. Ms. F. had to resort to cutting additional tiles out of construction paper and students had to wait turns to be able to use the tiles for their own work.

Next to the CE-Scale item (Appendix A) that states, *The lack of instructional materials and supplies makes mathematics teaching very difficult*, one teacher wrote in, *some have tools that others DO NOT. It's political!* And next to an item from the MTEBI (Appendix A) that states, *I find it difficult to use manipulatives and other models to explain to students why mathematics works*, a different teacher wrote in, *we need materials! Scales, rulers, meter sticks*. This lack of materials is limiting. An inventory of materials across the district and further information about budget allocation may help to determine specific needs in this area.

Curricular consistency. An additional factor identified by 40% of the coaches was the lack of a cohesive curriculum framework for mathematics instruction. Although this was not identified by school principals, when asked to describe how the materials/programs and instructional strategies used by teachers was determined at their individual schools, 80% responded that teachers used a combination of materials to meet student needs and did not necessarily follow the district mathematics curriculum framework. The district MISSLs also discussed curricular changes over the past few years resulting from administrative turn over. They explained that several years ago, a district mathematics curriculum framework based on the Common Core State Standards for Mathematics was developed, this was then replaced by the adoption of a single program that was required across the whole district but did not align with the district's framework. The new administration this year has again shifted the focus back to a standards-based curriculum framework and has identified restructuring the existing framework to reflect current understanding of the standards as well as increased school-based autonomy related to the strategic use of resources to better meet student needs as a district priority.

Comments from MSP grant PD discussions as well as in written exit feedback from these sessions, such as *why did we switch textbooks* and *it is really hard when we are using two* *different programs that present content in different orders and use different terminology,* indicate teachers are both uncertain as to how curricular resources have been chosen as well as frustrated with inconsistency across schools within the district. At the same time, teachers seemed to appreciate the opportunity to observe lessons in classrooms at other schools where they were able to see both similar and different programs being used. This led to several comments related to a desire to have access to multiple programs to, as one teacher wrote, *learn how to incorporate [them] into my own instruction and see how [they] align with the standards*.

Discussion

Student mathematics proficiency rates in Libertyville lag behind state averages and are particularly low for certain subgroups, including low SES, ELL, and minority students. In contrast to extant research, teacher characteristics, such as experience, mathematics knowledge for teaching (MKT), and mathematics efficacy for teaching (MEFT), commonly found to influence proficiency rates, did not consistently correlate with either identified student characteristics or student mathematics proficiency. A significant difference was found between teachers' individual and collective MEFT perceptions, with individual MEFT tending to be more positive than collective MEFT, especially for the mathematics coaches. Anecdotal evidence points to a lack of tie strength and collegial trust as potential mediators for collective MEFT. Because interpersonal conflicts and uneasiness with colleagues strain relationships and interfere with the exchange of resources within organizations, improving relationships may be an effective strategy for developing organizational capacity (Daly et al., 2009) and developing more positive collective MEFT perceptions (Goddard et al., 2004).

During discussions at the final MSP initiative meetings, teachers were asked to share ideas for sustaining the mathematics focused professional development work. Many of the ideas related to collaboration, including a desire to continue to have time to collaboratively plan with grade level colleagues, increased autonomy at grade level meetings, periodic PD sessions as refreshers during the summer and throughout the school year, and an online bank of tasks, lesson documents, student work, and other mathematics instructional materials. This appreciation for the value of collaborative opportunities was also a common theme in teachers' feedback throughout the PD sessions in comments such as, *I did the problems…I saw other people's work and it clicked* and *group discussions helped to clarify my understanding of the ideas and how to deliver lessons in my classroom*.

Building social capital as a tool for developing organizational capacity also aligns with the district's five-year plan which focuses on development of a cohesive mathematics instructional team by having the district MISSLs become a more consistent presence within the elementary schools to support the school based instructional leadership of the principals and mathematics coaches and develop consistency around instructional practices and student expectations. Additionally, the five-year plan calls for a shift in focus for the mathematics coaches themselves from school-based isolation to district-wide, collective accountability.

Social cognitive theory and its idea of triadic reciprocal determinism (Bandura, 1986) explains that achievement is shaped by the interaction of behavior (professional interactions or support networks), personal factors (teacher MKT and MEFT), and environmental or contextual factors (student and organizational characteristics; see Figure 1.1). Strong ties within and across professional support networks, especially those characterized by collegial trust and shared expertise, support the development of shared vision, knowledge, and commitment, all criteria for improved collective efficacy perceptions and student achievement (Coburn et al.; Coburn et al., 2012; Frank, Zhao, Penuel, Ellefson, & Porter, 2011; Shulman & Shulman, 2004). Therefore, determining a strategy for strengthening and expanding the professional support networks across Libertyville's elementary schools, thus increasing internal social capital, may be an effective approach to supporting achievement of the goals laid out in the district's five-year plan for improved mathematics teaching and learning.

Chapter 3: Intervention Literature Review

Like many public school districts in the U.S. (Jensen, Sonnemann, Roberts-Hull, & Hunter, 2016; Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009), Libertyville's professional development (PD) system currently addresses the problem of low student mathematics achievement through a top-down approach primarily consisting of didactic workshops aimed at filling perceived gaps in educators' mathematics knowledge for teaching (MKT), defined as the content and pedagogical skills and understandings needed for effective mathematics instruction (Ball et al., 2008). District administrators determine professional needs through student achievement data analysis and then use designated PD days to provide instruction in these identified areas.

Professional development consisting of occasional, additive instruction, where teachers are passive recipients expected to simply acquire pre-determined knowledge, can lead to learned helplessness and external attribution of their students' failure, a belief system that is difficult to reverse (Abrami, Bernard, Bures, Borokhovski, & Tamim, 2011; Linder, Eckhoff, Igo, & Stegelin, 2013). Professional learning cultures that limit teacher autonomy are especially prevalent in urban districts like Libertyville, where teachers have little influence over policies, training, or curriculum, diminishing job satisfaction and confidence in individual and collective ability to affect change and support student achievement (Donohoo, 2017; Wei et al., 2009).

An individual's perceptions of the collaborative attainment and affective ability of the educators within their school or district, also known as collective efficacy for teaching, better predict student achievement than factors such as the prior achievement levels or demographic characteristics of students (Goddard et al., 2000). In fact, based on data from over 1,200 meta-analyses of 195 teaching and learning factors, Hattie has ranked collective efficacy for teaching as having the strongest influence on student achievement with an effect size of 1.57, three times that of students' socio-economic status or home environment (Visible Learning, n.d.). Hattie (2012) proposes that positive collective efficacy for teaching supports effective teaching and student achievement by promoting educators' willingness to honestly analyze their impact on student learning success or failure and to openly engage in structured conversations with colleagues around this critique of personal practice.

In this study, collective mathematics efficacy for teaching (C-MEFT) describes a teacher's beliefs of group capability to effectively develop the mathematics skills and conceptual understanding students need for higher-order thinking, reasoning, and sense making. Efficacy for teaching is a task and context specific construct (Bandura, 1986; Pajares, 1996) dependent upon perceptions of the knowledge, commitment, and dispositions of others within one's professional networks. Therefore, "schools having both a supportive environment for teacher collective learning and application and a trusting atmosphere among colleagues tend to [demonstrate] more [collective] responsibility for students' learning" (Lee, Zhang, & Yin, 2011, p. 825). This does not appear to be the current, predominant culture in the Libertyville public elementary schools, where comments from district elementary mathematics coaches reflect perceptions that some of their colleagues attribute low student mathematics achievement to external factors, such as student characteristics and an unequal distribution of resources across schools. These comments may reflect negative collective efficacy perceptions, a lack of collegial trust, and a need for more collaborative learning opportunities to mobilize internal social capital, strengthen professional relationships, and increase teacher motivation to collaborate to develop professional knowledge, strengthen mathematics instruction, and support students' mathematics achievement (Dalyet al., 2009; van Es, 2012).

Developing Organizational Capacity

Existing contextual or environmental factors in complex social institutions, such as public schools, often limit collaborative reform efforts and organizational capacity, defined as a district's power to support both student achievement and professional learning (Andrews & Lewis, 2004; Cosner, 2009; McFadden, 2013). Efficient diffusion of existing resources enhances the professional community's effectiveness and overall organizational capacity. In public school contexts, efficient diffusion requires shifting change efforts away from top-down attempts to fix instructional weaknesses toward building upon professional strengths (Jensen & Luthans, 2006; Smith, Besharov, Wessels, & Chertok, 2012) by proactively developing internal leadership capacity and change agency (Onorato, 2013; Smith et al., 2012). Leader member exchange theory (House & Aditya, 1997) espouses that successful leadership does not stem from the characteristics or behaviors of a specific individual, but instead is based upon relationship systems, or professional support networks, characterized by trust, respect, and mutual obligation. It is thus the inter-relationships between situational conditions and relationship qualities that promote organizational success and vision attainment (House & Aditya, 1997; Ringleb & Rock, 2012).

By creating an environment that supports educator autonomy, school leaders develop individuals' sense of purpose and control increasing satisfaction and efficacy as well as productivity and group connectivity (Eyal & Roth, 2011; Rock & Cox, 2012). Affecting change within the Libertyville elementary schools may require increasing opportunities for high quality social interactions that foster collegial trust, improve C-MEFT, and efficiently distribute existing human, physical, and social capital throughout the organization (Daly et al., 2009; Spillane & Thompson,1997).

This literature review explores the influence of professional learning culture on a school district's ability to support the human and physical capital exchanges that determine social capital value and support the ongoing professional growth and student achievement that comprise organizational capacity.

Theoretical Framework

Strong social ties, characterized by collegial trust and shared expertise, support development of shared vision, knowledge, commitment, and support, all predictors of collective efficacy for teaching, student achievement, and organizational capacity (Coburn et al., 2013; Coburn et al., 2012; Frank et al., 2011; Shulman & Shulman, 2004). Professional development for elementary mathematics teachers in the U.S. consists primarily of isolated workshops disconnected from the classroom context (Jensen et al., 2016; Wei et al., 2009), limiting opportunities for teachers to collectively engage in the ongoing development of mathematics knowledge for teaching (MKT) and strong professional support networks (Ball et al., 2008; Ma, 2010; McCrory, Floden, Ferrini-Mundy, Reckase, & Senk, 2012; Shulman, 1986).

The relationships within these professional support networks are key to efficient information exchange and on-going professional learning. Individuals learn through social interactions as new meaning is negotiated and influenced by personal, environmental, and behavioral factors, or triadic reciprocal determinism (Bandura, 1986). In much the same way, social capital theory posits that organizational capacity, or the ability of a social institution to organize and manage itself toward achieving established outcomes, is influenced by three types of capital: human, physical, and social (Spillane & Thompson, 1997). In schools, organizational capacity is defined as the ability to promote both student achievement and educators' ongoing professional growth (Andrews & Lewis, 2004; Cosner, 2009) For mathematics instruction, this capacity is influenced by: (a) mathematics knowledge and efficacy for teaching (human capital); (b) contextual factors such as school culture and instructional resources (physical capital); and (c) the relationships and exchange of information within professional support networks (social capital; Figure 3.1).

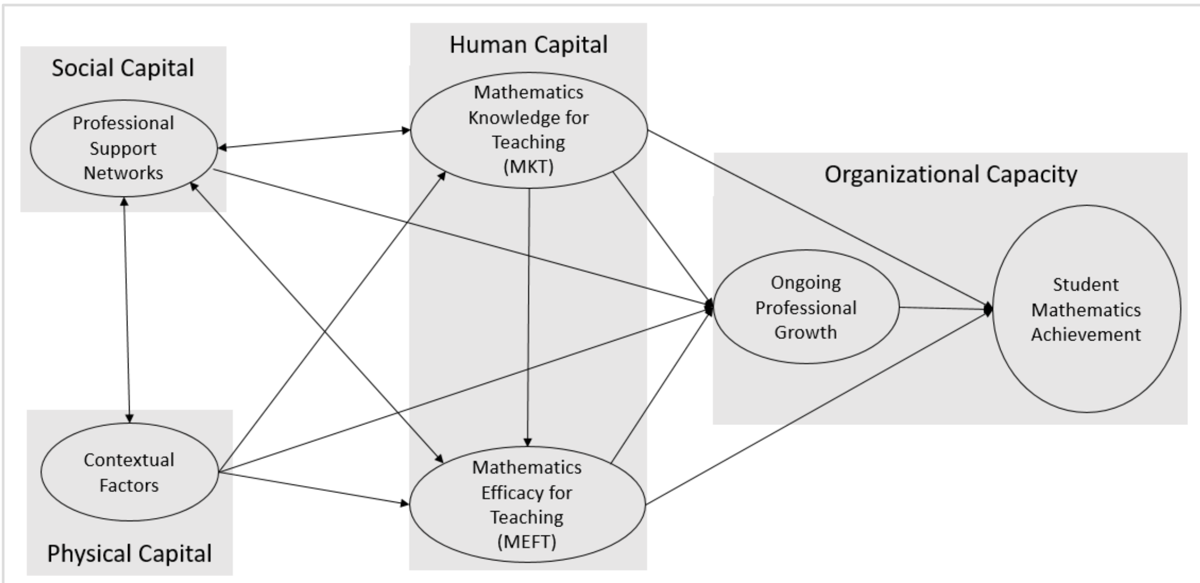


Figure 3.1. Conceptual framework of key factors contributing to problem of practice through the lens of social capital theory.

Leading Organizational Capacity Development

For educators, social capital is a function of perceptions of both individual and collective efficacies for teaching. Successful identification and activation of contextual factors, including structural and cultural preconditions, related to opportunity, motivation, and ability increases collaborative resource sharing and develops social capital (Minckler, 2014; Spillane, Hopkins, & Sweet, 2015). In this way, social relationships develop organizational value as a source of collegial trust, shared expertise, and overall human capital (Spillane et al., 2015).

The Libertyville school district lacks some of the organizational resources needed for capacity building, including collegial trust, mathematics knowledge for teaching expertise, and collective vision. Andrew and Lewis' (2004) Innovative Designs for Enhancing Achievement in Schools (IDEAS) is one model found to enhance collective professional capacity. This whole-school framework, piloted with a wide range of Australian educators, supports development of organizational identity and renews systemic engagement. The IDEAS teacher-centered approach calls for distribution of leadership to facilitate alignment of schoolwide professional learning, culture building, and pedagogical approaches to enhance both school capacity and collective efficacy for teaching (Andrews & Lewis, 2004). The IDEAS approach also supports Donohoo's (2017) enabling conditions for collective efficacy for teaching development, that include opportunities for teachers to contribute to and engage in consensus building school-wide decisions and policies, the development of a cohesive professional culture, and an atmosphere of leader concern and respect.

In Libertyville, development of a district-wide mathematics instructional community would increase opportunities for collaboration between district administrators, the district's two elementary Mathematics Instruction School Support Liaisons (MISSLs), the 20 school-based elementary mathematics coaches, and classroom teachers. The resulting increased autonomy and efficient relationship exchanges could build relational trust (Bryk & Schneider, 2003), support collective action (Ringleb & Rock, 2012), and create a cohesive vision for instructional change and organizational success (Bryk & Schneider, 2003; O'Connell, Hickerson, & Pillutia, 2010; Onorato, 2013).

Reform Oriented Professional Development

In addition to strong relationships, multiple factors influence engagement in instructional change, including the quality of available professional development opportunities and the type of learning resulting from those experiences (Loucks-Horsley & Matsumoto, 1999). To promote change, learning must be transformative, disrupting teachers' equilibrium (Loucks-Horsley & Matsumoto, 1999) and "chang(ing) deeply held beliefs, knowledge, and habits of practice" (Nelson, Perkins, & Hathorn, 2009, p. 1272). This process of transforming belief systems, unlike traditional additive learning that simply incorporates new skills into existing practice, is complex and only occurs over time through experimentation, reflection, and dialogue with experienced others (Frank et al., 2011; Nelson et al., 2009) engaged in learning both in and out of the classroom.

Transformative Learning Experiences

Effective teacher learning involves a series of learning experiences both inside and outside of the classroom that link cognition and experiential learning. Curry & Killion (2009) refer to these as micro and macro learning experiences. Macro learning experiences, often facilitated by external providers, involve collective cognitive learning opportunities that build common foundational knowledge within an organization. Micro learning experiences, on the other hand, involve the application and refinement of new knowledge within classroom practice. These micro learning experiences provide relevance for macro learning, an important step in the transformative learning process, and an important motivating factor for learner engagement and learning transfer (Richey, Klein, & Tracey, 2011). Micro learning experiences also de-privatize practice, engaging teachers in collaborative reflection involving classroom artifacts, such as achievement data, lesson plans, and student work samples (Curry & Killion, 2009). These connections to daily practice support learner motivation through the four elements of Keller's ARCS model by gaining learners' *attention*, providing *relevance* for new ideas, supporting the development of learner *confidence*, and increasing *satisfaction* with the learning process (Keller, 1987; Richey et al., 2011).

The professional development (PD) systems in most public-school districts in the U.S. do not combine micro and macro learning experiences in a systemic and sustained manner, relying instead upon isolated, didactic workshops often disconnected from classroom practice (Curry & Killion, 2009; Jensen et al., 2016; Loucks-Horsley & Matsumoto, 1999; Scotchmer, McGrath, & Coder, 2005; Vavasseur & MacGregor, 2008; Wei et al., 2009). This traditional PD model aims to fill fundamental knowledge gaps without requiring or supporting implementation or adaptation of that knowledge within daily practice (Curry & Killion, 2009; Wei et al., 2009). Reform oriented PD, on the other hand, promotes transformative learning by involving teachers in sustained collective, inquiry-oriented study of student learning and classroom practice (Curry & Killion, 2009). By combining micro and macro learning opportunities, this authentic inquiry goes beyond simply adding new ideas to existing repertoires, transforming beliefs and practice through collective reflection and intellectual discourse (Barnes & Solomon, 2014, Curry & Killion, 2009; Vavasseur & MacGregor, 2008; Wei et al., 2009) or what Lord (1994) describes as critical colleagueship.

Promoting Professional Discourse

Professional learning and change enactment requires productive disequilibrium in recognition that current practice could be improved. Collaborative dialogue around questions and concerns about current initiatives, policies, and issues exposes personal practice and enables educators to learn from constructive criticism and divergent perspectives, the crux of critical colleagueship (Lord, 1994). Scrutiny of personal practice, both individually and collectively, is not a core professional development practice in most U.S. school systems. As a result, it can feel unnatural and even painful (Males, Otten, & Herbel-Eisenmann, 2010). Carefully framing early critical discourse around structured conversations that stress clearly articulated statements of argument and evidence from shared referents, can establish common ground, promote critical feedback skills, and develop collegial trust. This groundwork can lead to an emotionally safe professional learning environment that values self-reflection, ambiguity and uncertainty, empathetic understanding, and collective generativity (Hamann, Lane, & Johnson, 2001; Lord, 1994; Males et al., 2010). A professional learning environment that promotes critical colleagueship and recognizes professional discourse as a source of improved practice as opposed to frustration and ill-will (Hamann et al., 2001).

Features of Effective Professional Learning Systems

In addition to centering on professional discourse around authentic inquiry, effective PD for K-12 educators shares several attributes, including: a focus on classroom teaching, job-embedded learning opportunities, and strategic alignment with existing initiatives and priorities (Croft, Coggshall, Dolan, Powers, & Killion, 2010; Garet et al., 2011; Jensen et al., 2016; Killion & Roy, 2009; Loucks-Horsley & Matsumoto, 1999; Scotchmer et al., 2005; Vavasseur & MacGregor, 2008; Wei et al., 2009). These features capitalize on teachers' knowledge and leadership potential and provide opportunities for teachers to share and develop knowledge together within the daily pursuit of supporting student achievement and their own professional growth (Lord, 1994).

Focus on classroom teaching and learning. Grounding professional learning opportunities on actual teaching and learning incidents within district classrooms provides a clear strategic focus and supports long-lasting instructional improvement (Jensen et al., 2016; Scotchmer et al., 2005). Collaborative learning experiences connected to specific student needs support content and pedagogical knowledge development and strengthen schoolwide capacity, as teachers learn from one another through shared practice (Loucks-Horsley & Matsumoto, 1999).

In their study of professional development in school systems around the world, Wei and colleagues (2009) found that the "U.S. is far behind in providing public school teachers with opportunities to participate in extended learning opportunities and productive collaborative communities" (p. 6). Although it is known that mathematics teachers need high-intensity, job-embedded collaborative learning opportunities to try out new techniques, activities, and materials to see how they fit into their own classroom contexts (Frank et al., 2011; Loucks-Horsley & Matsumoto, 1999; Wei et al., 2009), most PD in the U.S. continues to consist of workshops or other training sessions focused on developing specific skills or content knowledge and are not embedded within daily practice (Scotchmer et al., 2005; Wei et al. 2009). Garet et al.'s (2011) study of a multi-year mathematics' PD involving 92 teachers from middle schools (*n*=39) across the U.S., found that even when PD is time intensive, between 30 and 100 hours, neither teacher knowledge nor practice is significantly impacted unless explicit support is provided for classroom application.

Job-embedded learning opportunities. Job-embedded professional development views "professional knowledge as social, situated, and distributed among colleagues" and contained within and across "formal and informal social interactions among the teachers, situated in the context of their schools and the classrooms in which they teach" (Croft et al., 2010, p. 11). Sustained, job-embedded PD requires school governance structures and professional community cultures that actively involve teachers in collaborative decision-making and problem-solving around collectively identified areas of need (Jensen et al., 2016; Strahan, 2003; Wei et al., 2009).

Higher-performing education systems allow teachers to drive their professional learning in recognition of their value as professionals and needs as adult learners (Jensen et al., 2016). These bottom-up systems promote teacher agency by actively involving teachers throughout the process of directing their own professional growth as well as supporting that of their colleagues (Calvert, 2016). District administrators thus share leadership responsibility for school improvement planning with school principals, content experts and peer leaders within schools (Jensen et al., 2016). This shared leadership structure not only supports teacher autonomy and efficacy for teaching, but also increases access to ongoing, job-embedded guidance, advice, and mentoring that is specific to individual teacher needs (Calvert, 2016; Wei et al., 2009).

Full time, school-based mathematics coaches are well situated to promote instructional and programmatic change. Elementary mathematics coaches serve as instructional leaders in schools, without having administrative or evaluative responsibilities. Instead the coach's role is to work alongside classroom teachers to strengthen mathematics knowledge for teaching and instructional capacity (Campbell & Malkus, 2010; Weller, 2001). Their close daily contact with teachers and students places them in a particularly powerful position to personalize professional learning and promote instructional change (Weller, 2001).

In their study of elementary schools in Virginia (n=36), Campbell and Malkus (2010) found that experienced and knowledgeable mathematics coaches positively impacted both student mathematics achievement and teacher mathematics knowledge, practice, and beliefs, when provided time and opportunity to work closely with teachers inside of their classrooms. Unfortunately, many principals utilize mathematics coaches as a second school administrator, giving them additional responsibilities outside their assigned role as a mathematics instructional leader (Weller, 2001). This lack of alignment between job description and job responsibilities limits coaches' ability to promote teachers' mathematics professional growth (Andrews & Lewis, 2004; Campbell & Malkus, 2010; Weller, 2001), especially when coaches lack the leadership skills needed to advocate for time to work closely with teachers on specific mathematics teaching and learning issues (Campbell & Malkus, 2010).

Strategic alignment. Professional learning cycles begin by assessing student learning needs and move to determining how to best meet those needs and evaluate effectiveness of change efforts (Jensen et al., 2016). To effectively support both student and teacher learning needs, this professional growth cycle must align with the school improvement priorities and initiatives in both the district's and the state's strategic plans (Andrews & Lewis, 2004; Jensen et al., 2016; Wei et al., 2009). The alignment of strategic vision, professional learning culture, and instructional practice helps to ensure development of policies and structures that promote time and opportunities for collaborative professional learning to occur. A common vision is particularly powerful when policies tie performance evaluation of teachers and schools to the quality of these collaborative learning plans and their outcomes in terms of both professional growth and student achievement (Andrews & Lewis, 2004; Jensen et al., 2016).

Starting the professional inquiry cycle by empowering teachers to collaboratively analyze existing performance and practice data supports development of both a common vision and personal relevance. This process of "identifying and formulating the educational challenge is one of the foundational steps of any educational innovation… [as it] allows educational professionals to connect scientific research to their practice and acquire the skills to identify educational challenges and devise effective means for addressing them" (Mor & Mogilevsky, 2013, p. 12). Additionally, it promotes easy access to and co-construction of practice-based research and results in a learning culture that involves educators as partners in the development and implementation of professional learning not only for themselves, but also for those around them

(Anderson, 2008; Mor & Mogilevsky, 2013; Saderholm, Ronau, Rakes, Bush, & Mohr-Schroeder, 2016; Vavasseur & MacGregor, 2008).

Social Construction of Knowledge

Collaborative professional learning involves active knowledge creation through exploration, discussion, and productive discourse with peers (Vavasseur & MacGregor, 2008). This is different from the passive knowledge acquisition characteristic of traditional, additive PD models where trainers transmit information to teachers (Abrami et al., 2011; Linder et al., 2013). Instead, collaborative professional learning requires a systemic shift for professional learning from a top-down, provider focus to a bottom-up, learner focus (Anderson, 2008; Nelson et al., 2008). Just like student learning, professional development design is guided by learning theories which fall on a continuum between teacher centered instructivism, where teachers transmit established knowledge for learners to acquire, and learner centered constructivism, where teachers serve as guides for self-directed exploration and interpretation (Cercone, 2008), as new learning is "mediated by [learners'] own prior knowledge and [that] of others" (Reiser & Dempsey, 2011, p. 50). Although no one theory encompasses the styles and characteristics of all adult learners, existing theories provide frameworks to help better understand learning needs and the implications of instructional design decisions (Anderson, 2008; Reiser & Dempsey, 2011; Richey et al., 2011).

Constructivism and andragogy both promote active knowledge creation, with teachers or facilitators serving as guides for authentic, problem-based learning experiences (Anderson, 2008; Huang, 2002; Linder et al., 2013). Situated within actual work environments, this learning approach builds on existing, personally relevant practice and events (Croft et al., 2010) to connect prior knowledge, present application, and future implications in recognition of the value of adult learners' professional experiences and existing expertise (Cercone, 2008), increasing individual confidence and the likelihood of transfer to daily practice (Bonk & Khoo, 2014; Ernest et al., 2013). When connected to reflective, collaborative dialogue, these authentic learning experiences transform thinking and develops shared meaning as individuals "reveal feelings, explore assumptions [and] build common ground" (Chapman, Ramondt, & Smiley, 2005, p. 221), while collectively developing long-term, innovative solutions to practice-based problems (Akyol, Garrison, & Ozden, 2009; Anderson, 2008; Chapman et al., 2005).

Professional learning environments that promote teamwork, communication, shared leadership, and active participation and that allow individuals to make both personal and professional connections to diverse perspectives support social construction of knowledge (Ancar, Freeman, & Field, 2007). Meaningful discourse around differing points of view is a primary goal of constructivism (Gilbert & Dabbagh, 2005). As learners work to resolve conflicts or disagreements, they internalize their own views while also interpreting, analyzing, synthesizing, and evaluating the ideas of others (Benbunan-Fich & Arbaugh, 2006; Benbunan-Fich, Hiltz & Turoff, 2002; Gilbert & Dabbagh, 2005).

Shifting learning responsibility to learners requires both changed mindsets and careful attention to details of instructional design. To successfully choose a learning focus and to evaluate the appropriateness of solution strategies and related resources, learners need structured guidance and support from knowledgeable others, as well as access to a wide range of potential, well-vetted resources. Lacking guidance and support, ineffective activity is likely as learners are apt to direct their attention to unimportant tasks or details or waste time on vague information searching (Reiser & Dempsey, 2012). The integration of technology can support easy access to and more interaction between learners, between learners and content, and between learners and content experts, supporting work efficiency and helping learners make deeper connections between new ideas and daily practice (Anderson, 2008; Reiser & Dempsey, 2011; Thompson, Kitchie, & Gagnon, 2011).

Online Collaborative Learning

Collaborative leaning is a dynamic process that necessitates the merging of diverse perspectives and requires both inter- and intra-personal skills (Breen, 2015). Harasim's (2012) online collaborative learning theory espouses that this merging process occurs along a path from divergent to convergent thinking as communities of learners generate, organize, and converge ideas within an online or blended learning environment. Unlike traditional cooperative learning models, where there is a division of labor as individuals each contribute a part of a final product, collaborative learning involves the co-construction of a product through shared knowledge and understanding. The mutual engagement supported by sustained collaborative effort promotes group cohesion and interdependent learning (Breen, 2015), with the facilitator serving as a link to the larger, global professional community (Harasim, 2012; Henderson, 2007).

Online learning communities primarily reflect and interact via written, asynchronous communications. The asynchronous nature of online collaborative learning provides convenience and overcomes barriers of time and place, increasing opportunities for communication and collaboration between teachers who do not normally engage around shared practice. These increased interactions expand access to multiple ideas, problem solutions, and personal support, enhancing social capital within the organization (Vavasseur & MacGregor, 2008).

Garrison, Anderson, and Archer's (2003) community of inquiry framework posits effective online learning environments have three core elements: (a) social presence or engagement with other participants, (b) cognitive presence or engagement with content and ideas, and (c) teaching presence or engagement through management of the learning process. A combination of these three types of presence supports critical inquiry and reflective practice and decreases transactional distance as learning relationships develop and thrive (Bangert, 2008).

Supporting Online Collaboration

Being a unique form of communication that lacks typical verbal and non-verbal cues, online dialogue can impede this collaborative inquiry and reflective practice because it inhibits trust development, making individuals hesitant to communicate in an open manner (Anderson, 2008; Booth, 2012; Thompson & MacDonald, 2005). Additionally, a lack of familiarity with online tools and learning platforms aimed at supporting collaborative knowledge construction, can result in ineffective activity as learners expend effort attending to unimportant tasks, such as finding documents, instead of engaging in inquiry-based dialogue and exploration (Abrami et al., 2011; Ernest et al., 2013; Fusco, Haavind, Remold, & Schank, 2011; Reiser & Dempsey, 2012). Thus, specific attention must be given to developing fluency with appropriate technology skills and dispositions around how and when to use specific online tools, as well as to providing scaffolded opportunities for practice with peers of different ability (Abrami et al., 2011; Anderson, 2008; Ernest et al., 2013; Reiser & Dempsey, 2012; Richey et al., 2011) to allow learners to engage more productively in future complex learning tasks (van Merriënboer, Kirschner, & Kester, 2010).

A blended learning environment that incorporates regularly scheduled face-to-face sessions, provides opportunities for socialization, purposeful celebration of accomplishments, sharing of challenges, and accountability for work deadlines can help develop the collegial trust needed for effective online communication and engagement in an unfamiliar environment (Anderson, 2008; Cosner, 2009; Francis & Jacobsen, 2013; Thompson & MacDonald, 2005). By blending assets of both in-person and online communities with skilled facilitation and explicit norms for work and communication, a strong professional community can develop in a blended learning space, allowing for active social learning and dynamic knowledge creation across time and space (Chapman et al., 2005; Huang, 2002), ultimately resulting in stronger critical colleagueship as sustainable support for social capital development and engagement in instructional innovation (Minckler, 2014; Siemens, 2005) "by providing discourse communities that empower all participants... [and] provid(ing) contexts for members to challenge traditional, dominant cultural practices" (Caudle, 2013, p. 114).

Social Capital Development

Social capital theory posits that individual capacity exists within the structure and function of a broader network of exchange relationships and the creation of value through social networks both internal and external to the organization (Leana & Pil, 2006; Minckler, 2014). The value of social capital resides within the structural, relational, and cognitive facets of relationships (Leana & Pil, 2006) and manifests in both instrumental outcomes, or collective task accomplishment, and expressive outcomes, or satisfaction of an individual's need to belong (Minckler, 2014).

Influence on Organizational Performance

The collective nature of social networks, especially those characterized by collegial trust, strong connections, and shared vision, provides increased access to tangible and intellectual resources, or social capital, needed for organizational capacity development (Leana & Pil, 2006; Minckler, 2014). Leana and Pil's (2006) study of the effects of social capital on organizational performance in urban, K-12 schools (n=88) in a Northeastern district in the U.S. found that both internal and external social capital significantly and positively correlate with student achievement, but are also mediated by instructional quality, organizational culture, and breadth of professional exchanges. Intra-school ties, especially those residing within grade level teams, are more prevalent than inter-school ties (Leana & Pil, 2006; Spillane et al., 2015), however those ties that span across grade levels or schools contain more information, diverse perspectives, and novel ideas (Spillane et al., 2015).

Establishing environmental conditions and structures conducive to inter-school and intergroup professional network development and communication increases access channels to organizational resources and capital (Andrews & Lewis, 2004; Minckler, 2014). This enhanced collaborative environment and resource exchange capacity supports the performance of even lower-ability teachers, thus increasing overall knowledge, skills, and dispositions, or human capital (Leana, 2011), which in turn enhances the "resources available to and used by teachers by virtue of membership in social networks to produce [desired] outcomes", or social capital (Minckler, 2014, p. 658). In a study of mathematics teaching and learning in 130 elementary schools in New York City over a two year time period and involving 2,200 teachers, Leana (2011) found that although the combined effects of human capital and social capital within a district results in the greatest amount of student learning, high levels of social capital can compensate for human capital deficiencies, in that "if a teacher's social capital was just one standard deviation higher than average, her student's math scores increased by 5.7%", meaning that social capital is a "significant predictor of student achievement gains above and beyond teacher experience or ability in the classroom" (p. 33). These findings led to the conclusion that "building teacher human capital…will not yield the qualified teaching staff so desperately needed in urban districts. Instead, policymakers must also invest in measures that enhance collaboration and information sharing among teachers…[because] talking to peers about the complex task of instructing students is an integral part of every teacher's job and results in rising student achievement" (Leana, 2011, p. 35).

Shaping Organizational Culture

Through modeling and interactions, school leaders can shape this type of organizational culture and influence both individual and group behaviors as they work toward developing organizational capacity, including effective professional learning environments (Minckler, 2014). Studies in both face-to-face and online communities have found that when leaders' task- and relations-oriented behaviors infuse intellectual stimulation into professional support networks (Minckler, 2014), social capital, including a collaborative culture and collective action planning, develops and supports vision attainment (Faraj, Kudaravalli, & Wasko, 2015; Geijsel, Sleegers, Leithwood, & Jantzi, 2003; Kahai, Jestire, & Huang, 2013; Minckler, 2014).

Shared leadership supports professional community development by shifting from "the belief that leadership is a unique characteristic that an individual has developed to a belief that teachers have a pragmatic understanding of the needs of the school and the school community as well as individual sets of skills and knowledge" (Nappi, 2014, p. 33). The resulting aggregated effort and enhanced cooperation encourages active participation in decision-making, develops feelings of ownership and autonomy, and increases the likelihood of instructional innovation and student success (Nappi, 2014). For example, Bryk, Camburn, and Louis' (1999) study of 5,690 elementary teachers from 248 Chicago public schools showed strong professional communities that foster instructional change develop in schools where norms and support structures encourage risk taking and experimentation.

Developing internal leadership. Leader membership exchange theory (House & Aditya, 1997) espouses that promoting teachers' abilities to determine their own path for continual professional growth (Onorato, 2013) supports the development of a collective vision. Additionally, allowing teachers to participate in decision making (Geijsel et al., 2003) enhances their efficacy for teaching. These types of shared leadership opportunities, in both face-to-face and on-line professional communities, encourage member ownership and create a stronger sense of community and collective accountability (Bryk et al., 1999). This collaborative atmosphere and sense of autonomy creates empowerment, making professional communities less vulnerable to external factors such as administrative turn-over and shifting policies (Kennedy & Smith, 1999) common in urban districts (Darling-Hammond, 1997), such as Libertyville.

Professional community effectiveness and overall organizational capacity necessitate efficient diffusion of social, human, and physical capital. School leaders mediate information exchange through organizational systems and structures that impact social network ties. Perceived as having content expertise and situated near teachers, subject leaders, such as school-based mathematics coaches, become the primary conduit of expertise both within and between schools (Friedman, 2011; Spillane et al., 2015). Whether these school-based instructional leaders function more as transformational leaders or managers depends on district leaders' vision for their professional development role and willingness to share leadership responsibility, as well as the competence, both perceived and actual, of the mathematics coaches themselves (Friedman, 2011).

Development of Organizational Capacity

The Libertyville School District may benefit from increased opportunities for high quality social interactions to develop collegial trust, increase collective mathematics efficacy (C-MEFT) perceptions, and efficiently distribute existing human, physical, and social capital (Daly et al., 2009; Spillane & Thompson,1997). Accomplishing this within a complex environment requires attention to the interaction of multiple variables to “energize people into action, develop followers into leaders, and transform organizational members into agents of change” (Van Seters, 1990, p. 41). This work starts by developing “high quality relationships…characterized by trust, respect, and mutual obligation [and] generating mutual loyalty and influence between superiors and followers” (House & Aditya, 1997, p. 431), including the relationships involving Libertyville’s district elementary Mathematics Instructional Support Liaisons (MISSLs) and the school based elementary mathematics coaches whom they support.

Professional collaboration, especially between individuals with differing backgrounds and experiences, supports organizational capacity building as teachers see themselves as members of a community of learners (Jaquith et al., 2011; Minckler, 2014). Having recently participated in a district wide professional development initiative that allowed them to meet regularly with inter-school colleagues, Libertyville elementary mathematics coaches recognize the value of opportunities to discuss pedagogical change and knowledge development with inter-school colleagues. These exchanges create social capital and provide a means of distributing existing human and physical capital, thus supporting organizational capacity development (Daly et al., 2009; Spillane & Thompson, 1997). Sustained opportunities for critical colleagueship around a single collective purpose also lead to deeper understanding, more divergent thinking, re-evaluation of assumptions, and increased application to classroom practice, necessary factors for change enactment and ongoing professional growth (Geijsel et al., 2003; Kintz, Lane, Gotwals, & Cisterna, 2015; Wilson & Berne, 1999).

Bryk, Camburn, and Louis (1999) explain that “when teachers trust and respect each other, a powerful social resource is available for supporting collaboration, reflective dialogue, and deprivatization” (p. 767) of practice, leading to greater student achievement and professional growth (Strahan, 2003). Collegial trust is critical for organizational capacity building (Cosner, 2009), as it is positively correlated to task performance, team satisfaction, relationship building, and collective efficacy development (Costa, Roe, & Taillieu, 2001; Lee, Zhang, & Yin, 2011). The collaborative inquiry and critical colleagueship made possible through strengthened relationships encourages ongoing growth and innovation, as individuals openly exchange ideas, solve problems, develop collective understanding, critically self-reflect, and support implementation of alternative practices (Andrews & Lewis, 2004; Vavasseur & MacGregor, 2008) indirectly leading to sustained professional growth and increased student achievement (Leana & Pil, 2006; Minckler, 2014).

Intervention Design Implications

Grounded in the principle of social cognitivist and social capitalist theories that learning occurs through social interactions (Bandura, 1986; Minckler, 2014), this intervention design is based on the theory of change (Figure 3.2) that if educators have increased opportunities to engage in purposeful conversations and authentic inquiry around student performance with inter-school colleagues (Cosner, 2009; Francis & Jacobsen, 2013; Kintz et al., 2015; Strahan, 2003), then an upward spiral will develop promoting positive collective mathematics efficacy for teaching and internal social capital (Booth, 2012; Geijsel et al., 2003). Changed professional beliefs, in turn, lead to increased motivation for active engagement in change processes (Geijsel et al., 2003; Kintz et al., 2015) and sustainable collaborative inquiry (Andrews & Lewis, 2004; Bryk et al., 1999; Vavasseur & MacGregor, 2008).

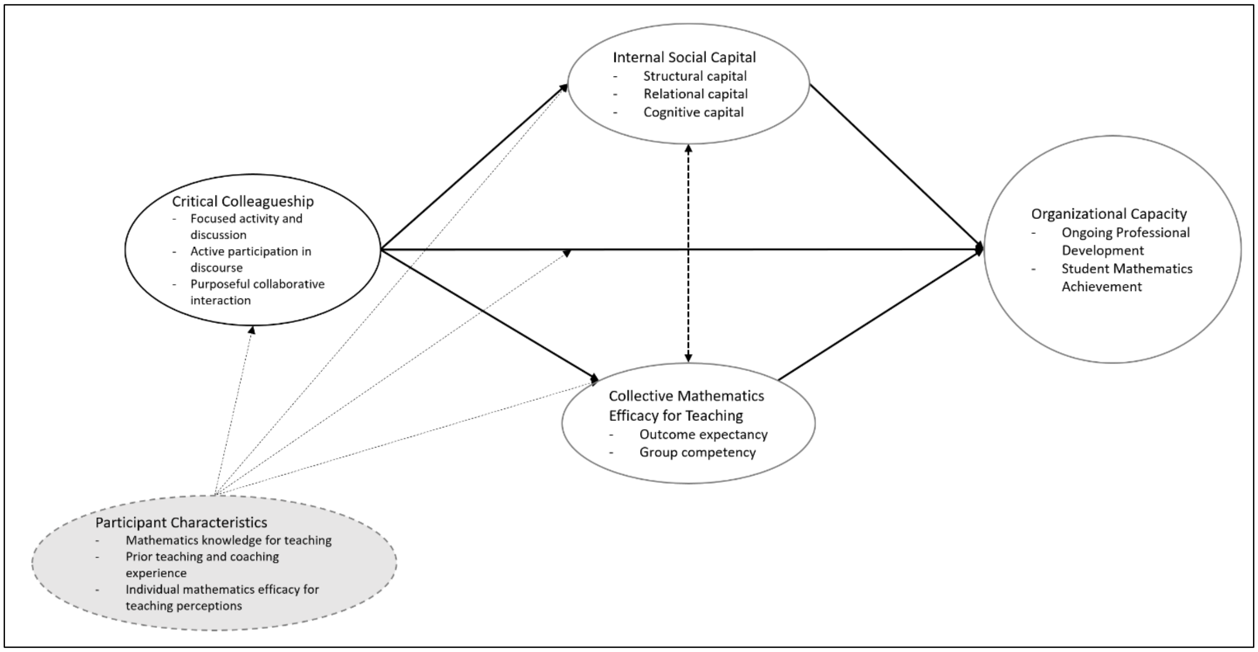


Figure 3.2. Theory of change diagram for intervention design.

Critical Colleagueship and Internal Social Capital

Social capital theory posits that relationships and the exchange of resources through professional support networks have value and therefore are a form of capital within organizations (Minckler, 2014). Social capital value is in part determined by the frequency, intimacy, and number of existing social ties within a given professional support network (Moolenaar et al., 2012). In Libertyville, the mathematics coaches are spread out across the 22 elementary schools in the district, presently have limited collaborative opportunities, and lack access to a shared pool of resources including student data, classroom artifacts, and curricular materials. Developing collaborative, inter-school work groups has the potential to increase critical colleagueship and expand the number and types of professional relationships within the Libertyville Public School District, thus supporting the diffusion of expertise and increasing internal social capital (Kaser & Halbert, 2014; Spillane et al., 2015). In turn, more efficient and effective transmission of resources and information throughout the district should increase human capital and ultimately organizational capacity (Figure 3.2).

Critical Colleagueship and Collective MEFT

Regularly engaging in purposeful, professional conversations around student performance, a key feature of critical colleagueship (van Es, 2012), builds cohesion around teaching and learning, allows for need prioritization, and creates an upward spiral promoting positive collective efficacy for teaching and stronger agency toward supporting student achievement (Booth, 2012; Geijsel et al., 2003; Strahan, 2003). Additionally, the supportive relationships developed through critical colleagueship increase collegial trust and promote a safe and engaging learning environment, allowing increased risk taking, more reflective practice, and development of more positive collective MEFT perceptions (Figure 3.2; Hardiman, 2012; Kennedy & Smith, 2013; Linder, Post, & Calabrese, 2012).

Internal Social Capital and Collective MEFT

Higher levels of collective MEFT positively impact the exchange of resources and patterns of social relationships leading to effective collective action, goal achievement, and improved instructional practices (Moolenaar et al., 2012). Conversely, collective MEFT is influenced by contextual factors such as organizational climate and the exchange of resources and knowledge through professional support networks (Figure 3.2; Darling Hammond, 1997; Goddard et al., 2000; Shulman & Shulman, 2004).

Assumptions and External Factors

Instructional effectiveness, and indirectly student achievement, is influenced by mathematical knowledge for teaching (MKT; Ball, 1990; Ball et al., 2008), individual MEFT, and prior experience (Goddard et al., 2000; Valli & Buese, 2007). Individual MEFT and MKT are positively correlated to educators' effort (Hill, 2010; Moolenaar et al., 2012; Smith et al., 2005) and a focus on the purposive actions needed to achieve organizational goals and create a normative environment that positively influences teaching behaviors and supports a culture of continuing collaborative growth (Goddard et al., 2000). The interaction of human capital, defined as professional knowledge and beliefs, with the social capital within professional relationships determines whether organizational factors support or impede professional growth and instructional transformation. Inadequate knowledge, skills, motivation, or support within these networks weaken interactions and limit organizational capacity (Figure 3.2; Daly et al., 2009; Shulman & Shulman, 2004).

Professional experience impacts perceptions of others' competence and thus collective MEFT (Bandura, 1986; Goddard et al., 2000). Teacher experience is also often used as a proxy measure for expertise and knowledge (Hill, 2007; Smith et al., 2005) and is positively correlated with both student achievement (Okpala, Smith, Jones, & Ellis, 2000) and efficacy for teaching (Chetty et al., 2014; Cobb & Jackson, 2015; Hill, 2007). Additionally, perceived competence and transparency around expertise supports collegial trust (Booth, 2012), an important component of critical colleagueship, collective MEFT, and social capital (Goddard et al, 2000; Leana & Pil, 2006; van Es., 2012).

Summary of Literature Review

A social learning perspective sees knowledge development as both an intellectual and a social endeavor requiring active engagement by the learner as understanding is socially negotiated through interaction and experience (Akyol et al., 2009; Bandura, 1986). Collaboratively engaging in inquiry around authentic, practice-based problems is a social learning experience that provides educators with relevant, common learning experiences

(Bangert, 2008), promotes an "environment that is supportive intellectually and socially… [encouraging] meaningful discourse and develop(ing) personal and lasting understanding of [content]" (Rourke & Kanuka, 2009, p. 21). When enacted effectively, collaborative inquiry "can develop from being used as a tool to enable teachers and educators to explore key questions and issues in practice to becoming a 'way of being' through which participants in a community develop their practices" (Hunter & Back, 2011, p. 97).

Engaging the Libertyville's elementary MISSLs and elementary mathematics coaches in inter-school inquiry teams within a blended learning environment is one strategy to promote collaborative problem solving around self-identified goals aligned to the district's vision for mathematics instruction, professional growth, and student achievement (Andrews & Lewis, 2004; Booth & Kellogg, 2015; Daly et al., 2009; Goddard et al., 2000; Strahan, 2003; Vavasseur & MacGregor, 2008). Promoting autonomy through shared leadership, as part of the collaborative inquiry design, should increase job satisfaction and efficacy for teaching, as well as overall productivity and connectedness between group members (Eyal & Roth, 2011; Faraj et al., 2015; Geijsel et al., 2003; Kahai et al., 2013; Minckler, 2014; Rock & Cox, 2012). By blending assets of both in-person and online communities with skilled facilitation, a strong professional learning community will potentially develop allowing for active social learning and dynamic knowledge creation (Chapman et al., 2005; Huang, 2002), ultimately resulting in sustainable support for organizational capacity (Figure 3.2).

Chapter 4: Intervention Procedure and Program Evaluation Methodology

According to their website, the Libertyville Public School District strives to prepare students for college and career success through educators' collaborative team work and shared responsibility. Needs assessment findings from spring 2016 (see chapter 2) showed a lack of strong professional support networks and negative perceptions of collective mathematics efficacy for teaching (C-MEFT), especially amongst the mathematics coaches, impeded these elementary educators' ability to meet students' mathematics learning needs. Unlike traditional efforts that infuse new skills and knowledge into a system (Abrami et al., 2011; Linder et al., 2013; Wilson & Berne, 1999), the purpose of this intervention design was to build upon existing social, human, and physical capital in the district to develop sustainable support for organizational capacity growth (Minckler, 2014; Wilson & Berne, 1999).

In school settings, organizational capacity is defined as the ability of a district to promote student achievement and ongoing professional growth (Andrews & Lewis, 2004; Cosner, 2009). Interpersonal conflicts and uneasiness with colleagues, often the result of limited collegial trust, strain relationships and interfere with resource and knowledge exchanges, limiting organizational capacity and internal social capital development (Coburn et al., 2013; Coburn et al., 2012). Critical colleagueship within professional support networks, defined as the promotion of professional disequilibrium through the critical analysis of existing instructional practices and beliefs (Lord, 1994; van Es, 2012), promotes organizational capacity by increasing shared understanding, supporting C-MEFT development, mediating the impact of contextual factors, (Coburn & Russell, 2008; Jaquith et al., 2011; Shulman & Sherin, 2004), and helping disseminate information and knowledge throughout the organization (Cobb & Jackson, 2015;

Francis, 2009; Frank, Zhao, Penuel, Ellefson, & Porter 2011; Moolenaar et al., 2012; Valli & Buese, 2007).

Teachers in Libertyville tend to seek professional advice from those in closest proximity, including grade level team members and the mathematics coach assigned to their school (see Figure 2.7). Although this type of proximal advice seeking is common, intergroup and inter-school knowledge exchanges expand access to broader skill sets and more diverse perspectives, thus providing better support for ongoing professional growth and positive C-MEFT perceptions (Goddard et al., 2000; Moolenaar et al., 2012; Spillane, Hopkins, & Sweet, 2015). Increasing inter-group and inter-school knowledge exchanges is particularly important in Libertyville where elementary educators lack confidence in collective mathematics teaching ability and collegial trust, indicating a need for stronger and broader support networks to mobilize internal social capital and increase beliefs in collective capacity (Daly et al., 2009).

Theory of Treatment

According to social cognitive and social capital theories social interactions promote learning and change motivation (Bandura, 1986; Minckler, 2014). Critical colleagueship amplifies this effect (Lord, 1994; van Es, 2012). Based on these theoretical foundations (Leviton & Lipsey, 2007), this study's treatment theory posited that increased opportunities to engage in collaborative inquiry and develop critical colleagueship with inter-school colleagues (Cosner, 2009; Strahan, 2003; Thompson & MacDonald, 2005) would promote positive perceptions of C-MEFT and internal social capital (Booth, 2012; Geijsel et al., 2003; Minckler, 2014), precursors to sustainable professional growth, student achievement, and organizational capacity development

(Andrews & Lewis, 2004; Bryk, Camburn, & Louis, 1999; Geijsel et al., 2003; Kintz, Lane, Gotwals, & Cisterna 2015; Vavasseur & MacGregor, 2008).

Treatment Design

Regularly engaging in purposeful conversations around daily practice helps build the cohesion, collegial trust, and supportive relationships needed to support the public self-reflection and professional discourse required for critical colleagueship development (Lord, 1994; Kintz, et al., 2015; van Es, 2012). As the logic model in Figure 4.1 shows, engagement in practice based, structured inquiry around self-identified goals aligned to district and school priorities for mathematics teaching and learning provided opportunities for the 20 mathematics coaches and Mathematics Instruction School Support Liaison (MISSL) from Libertyville's elementary schools to develop critical colleagueship altogether and in small teams (see logic model in Figure 4.1).

Incorporated within existing district structures, this blended learning design included three main components: (a) an online collaborative space for resource sharing and communication, (b) monthly online team meetings to promote accountability, and (c) monthly in-person meetings to strengthen professional support networks and collective accountability within and across teams. This combination allowed participants to take advantage of online features to overcome barriers of time and place normally associated with inter-school collaboration (Blitz, 2013; (Geijsel et al., 2003; Minckler, 2014; Vavasseur & MacGregor, 2008), while still providing opportunities to develop trusting relationships through face-to-face interactions (Anderson, 2008; Thompson & MacDonald, 2005; Figure 4.1).

Resources/Personnel	Activities: Inquiry Work	Activities: Evaluation	Outputs (Mediating Variables)	Outcomes (Dependent Variables)	Impact
Personnel: Interschool inquiry teams of elementary mathematics coaches (5-6 coaches/team; 21 total participants) Team facilitation by 2 district elementary Mathematics Instruction School Support Liaisons (MISSLs) Administrative support from district's mathematics leadership team members Technology troubleshooting and support from Office of Innovation instructional specialist **Resources:** District five-year plan for student achievement and professional learning for mathematics Instructional rounds data from 2016-17 school year, including recommendations for School Improvement Plans Space within the district online platform for inquiry work Meeting space with internet and technology access **Time:** Time at regularly scheduled monthly in-person mathematics coaches' meetings (2-3 hours) Time for monthly synchronous meetings within coaches' regular schedule (2-3 hours)	**Blended design for inquiry team work:** 6 two-three hour in-person (f2f), all coach sessions, (1/month); MISSLs & author facilitating - *Aug-Sept 2017*: Establish team charters, inquiry goals, & achievement plans - *Monthly:* Cross-team feedback and support; achievement plan revision; and development of interpersonal relationships, collective accountability, & relevant skills & knowledge - *Jan-Feb 2018:* Evaluation and presentation of work 6 two-three hour online, synchronous sessions, each team; MISSL facilitating (1/month) - Relationship building - Work accountability - Problem solving - Resource sharing - Achievement plan revision Ongoing asynchronous collaboration within daily work schedule - Achievement plan work - Cross-team feedback - Connection to daily work **Shared online resource and work space:** Creation & monitoring of designated online space to support collaboration, communication, resource sharing, & skill development (author & instructional specialist to structure & monitor)	**Evaluation** *Aug. 2017*: Pre-assessment of collective MEFT and Internal social capital perceptions (Coaches) *Aug 2017 – Feb 2018*: Author will archive asynchronous communications; synchronous & f2f meetings will be recorded & transcribed to provide critical colleagueship data for qualitative analysis *Sept 2017 – Feb 2018*: System functionality feedback gathered at monthly f2f meetings using Google forms (coaches & MISSLs) *Feb 2018*: Post-assessments for collective MEFT and internal social capital perceptions (coaches)	**Critical colleagueship development:** Increased collaborative discussions about mathematics teaching and learning (collaborative interactions) Increased engagement in collaborative discourse around mathematics teaching and learning (participation and discourse norms) Increased focus of discussions specific to mathematics teaching and learning in district classrooms/schools (focus of activity & discussion)	**Short term:** ***Collective mathematics efficacy for teaching:*** More positive perceptions of collective ability to promote student mathematics learning across the district (task analysis) More positive perceptions of collective skills, pedagogy, and expertise in mathematics across the district (group competency) ***Internal social capital:*** More positive perceptions of structural capital across the district More positive perceptions of relational capital across the district More positive perceptions of cognitive capital across the district **Intermediate:** Increased mathematics knowledge for teaching More effective instructional practices in mathematics	***Increased organizational capacity:*** - Ongoing professional growth - Student mathematics achievement

Assumptions:	**External Factors:**
Coaches will authentically and actively engage in the collaborative inquiry work. Coaches will provide honest feedback and responses for the evaluation. MISSLs will continue to support the work, including providing time at the monthly coaches' meetings and each facilitating two inquiry teams. Coaches and MISSLs will be able to collaborate effectively online as well as in person. District administrators will continue to support the project and provide IRB approval.	Participants existing knowledge, skills, beliefs, and prior experiences Other district initiatives. District controlled online platform. Turnover of coaches, meaning there will be individuals who have not participated in the planning process this year. The instructional specialist supporting the development and monitoring of the online platform will have different job responsibilities next year.

Figure 4.1. Logic model for intervention design.

Outcome Evaluation

Sound research design requires attention to both anticipated outcomes and the processes involved in promoting those outcomes in terms of efficiency and effectiveness (Rossi, Lipsey, & Freeman, 2004). Enhanced organizational capacity, in terms of both ongoing professional learning and student mathematics achievement, is the anticipated long-term impact of this intervention as the treatment theory indicates (see Figure 4.1). Shifting professional culture, changing core beliefs about effective mathematics instruction, embedding new approaches into classroom practice, and seeing the impacts of these changes in student performance all take time and may not be visible within the six-month time frame of this intervention evaluation (Daly et al., 2009; Minckler, 2014; Ross & Bruce, 2007; Shulman & Shulman, 2004; Woolfolk Hoy & Spero, 2005). Therefore, the outcomes of focus for the evaluation of this intervention are precursors to these shifts, specifically changes to the C-MEFT and internal social capital (ISC) perceptions of Libertyville's 20 elementary mathematics coaches (see Appendix G for evaluation matrix). These short-term, proximal outcomes are measurable within the six-month time frame and have been found to promote change processes such as engagement in a new professional learning system, a first step in promoting organizational capacity (Leana & Pil, 2006; Minckler, 2014; Moolenaar et al., 2012; Puchner & Taylor, 2006; van Es, 2012).

Process Evaluation

An evaluation of changed perceptions of C-MEFT and internal social capital will not conclusively determine intervention effectiveness unless implementation and intervention fidelity are also evaluated. The process evaluation plan for this study promoted the systematic analysis of implementation fidelity and was conducted both formatively, to adapt intervention structures and processes to meet emerging needs, and summatively, to determine the degree of implementation success and to help interpret and explain the outcome evaluation results. Such an analysis required consideration of several aspects of implementation fidelity, including the extent to which the intervention was fully implemented, the dose delivered to and received by participants, the reach in terms of intended participants, and the influence of contextual factors (Dusenbury, Brannigan, Falco, & Hansen, 2003; Saunders, Evans, & Joshi, 2005).

This intervention was considered fully implemented if 100% of the elementary mathematics coaches (n=20) and MISSLs were actively involved in all three components of the blended learning environment: seven in-person meetings, five synchronous online meetings, and ongoing asynchronous online collaboration for the duration of the intervention (six months). Implementation fidelity was considered low if (a) less than 90% of participants were actively involved in all three collaborative inquiry components, (b) more than one individual from any given team missed more than two meetings, and/or (c) more than one individual from any given team did not contribute asynchronously at least one time per month. Failure to establish a viable collaborative inquiry team (CIT) action plan or team charter or failure to complete more than one of their "small-win" action steps (see Appendix A) by one or more teams also indicated low fidelity.

To determine implementation fidelity, the following tools and artifacts were gathered and analyzed. An analysis of attendance records, meeting transcripts, and online interaction archives determined active involvement. The extent to which the collaborative inquiry process was implemented was also evident within each CIT plan (Appendix H), team charter for collaborative norms (Appendix I), and monthly update reports at in-person meetings. Analysis of these documents provided information around implementation fidelity and dosage, showing the establishment of clear norms for collaboration in the three different spaces and a structured inquiry process plan, as well as adherence to and completion of these plans. Meeting transcripts, interaction archives, and monthly feedback surveys (Appendix J) also provided insight into contextual factors that impeded and promoted the collaborative inquiry process.

For this intervention, the output of interest was not the achievement of the specific CIT plan itself, but instead the development of critical colleagueship and strengthening of inter-school professional relationships. Therefore, an analysis of the dosage received required an examination of transcripts, asynchronous online interactions, and participant feedback for evidence of critical colleagueship, active collaboration, and participant satisfaction. The complete process evaluation determined intervention and implementation fidelity through an examination of whether critical colleagueship developed within CITs and whether specific program structures and systems were in place to support coaches' and MISSLs' active participation and engagement in the process (see Appendix G for evaluation matrix).

Methodology

Using an embedded, mixed methods design [QUAN(+qual)], the evaluation of this intervention sought to simultaneously use (a) quantitative survey and questionnaire data to demonstrate whether educators' involvement in inter-school inquiry groups positively influenced resource exchanges by improving perceptions of C-MEFT and internal social capital and (b) qualitative data from participant interactions and feedback to explore the intervention structures and processes that both supported and impeded collaborative professional learning (Creswell & Clark, 2011; Teddlie & Tashakkori, 2003).

Research Questions

The outcome evaluation of this intervention (see Appendix G) took an observational approach to examining connections (Leviton & Lipsey, 2007) between levels of critical colleagueship within inter-school inquiry teams of mathematics coaches and changes to those individuals' perceptions of C-MEFT and ISC. Specifically, the outcome evaluation sought to answer the following research questions:

- How does critical colleagueship influence educators' perceptions of collective mathematics efficacy for teaching (C-MEFT)?
- How does critical colleagueship influence educators' perceptions of internal social capital (ISC) related to mathematics instruction within a school district?

Additionally, the process evaluation formatively and summatively examined intervention and implementation fidelity by determining utilization of program components, individual participation and engagement, and development of critical colleagueship within inquiry teams. Correlations between these elements was also determined to help explain outcome results and inform the improvement of the overall program for future iterations. Specifically, the process evaluation sought to answer the following research questions:

- How does engagement in structured collaborative inquiry within a blended learning environment impact the degree of critical colleagueship amongst a group of mathematics educators over time?
- Which structures and systems of a blended learning environment promote and impede critical colleagueship amongst mathematics educators within collaborative inquiry teams?
- How do differing levels of engagement within collaborative inquiry teams influence development of critical colleagueship amongst mathematics educators within a blended learning environment?

Participants and Recruitment

This six-month intervention was implemented and evaluated in the Libertyville Public School District, the site of the needs assessment. Of the many project stakeholders within the district (see stakeholder analysis, Appendix K), the most active and integral were the 20 school-based, elementary mathematics coaches and the elementary Mathematics Instruction School Support Liaisons (MISSLs). Study participants were recruited by the researcher at a district sponsored, elementary mathematics coaches' professional development day in August 2017. At this session individuals were introduced to the study (see recruitment script; Appendix R). Upon providing consent, participants completed an assessment of their perceptions of both C-MEFT (Appendix M) and ISC (Appendix N), that served as baseline data for the outcome evaluation.

Elementary mathematics coaches. Except for one coach who supports two small schools, the 20 elementary mathematics coaches each work full time at one of the district elementary schools. In addition to serving as a member of their school's instructional leadership team, these educators provide mathematics instructional coaching for classroom teachers, run bi-weekly common planning time (CPT) meetings with each grade level team, and oversee district and state mathematics assessment administration and analysis. They also serve as a link between the district's mathematics leadership team and their school principals, keeping them abreast of mathematics curricular and instructional initiatives.

All 20 school-based, elementary mathematics coaches consented to participate in the study. Participation included agreeing to (a) complete the pre- and post-assessment of C-MEFT and ISC perceptions (Appendices M and N), (b) provide monthly process feedback through an online survey (Appendix J), (c) permit audio recording of monthly in-person and virtual meetings, (d) permit monitoring of online interactions related to their collaborative work, and (e) engage in collaborative inquiry with a small team through monthly in-person and virtual meetings and independent school-based application

As can be seen in Table 4.1, most coaches were females (*n*=17). Their coaching experience ranged from less than one year up to 17 years (*M*=6.78). Roughly two-thirds of the participants (*n*=12) worked as elementary classroom teachers prior to becoming mathematics coaches, with the remaining coaches having worked as middle (*n*= 7) or high school mathematics teachers (*n*=1). All but two of the coaches have worked in the district for most of their careers. The remaining two participants worked as elementary mathematics coaches in districts outside of the state prior to coming to Libertyville.

Table 4.1.

Participant characteristics

Team	Gender	Coaching Experience	Prior Experience
A	f=3; m=1	*M*=7.0 (min=3; max=17)	2 elem., 1 MS, 1 HS
B	f=5; m=1	*M*=5.2 (min=1; max=12)	4 elem., 2 MS
C	f=5; m=1	*M*=8.7 (min=3; max=17)	4 elem., 2 MS
D	f=3; m=1	*M*=6.3 (min=2; max=12)	2 elem., 2 MS

Note. f = female; m = male; elem = elementary school; MS = middle school; HS = high school

Each coach worked as a member of one of four collaborative inquiry teams (CITs) for the duration of the study. District administrators requested team membership be structured around ongoing inter-school cohorts established during the 2016-2017 school year for purposes of supervision, evaluation, and teaching and learning support. As a result, CITs were comprised of either four or six coaches, based on school factors such as location and student learning programs such as bilingual classrooms.

Mathematics Instruction School Support Liaisons (MISSLs). As members of the district's mathematics leadership team who report directly to the Supervisor for Mathematics Teaching and Learning and the Director of Curriculum and Instruction, the MISSLs serve as a direct link between district administration and the elementary schools by supporting and coordinating the work of the school based, elementary mathematics coaches and ensuring implementation of district initiatives. Among the MISSLs' responsibilities is oversight of professional development for elementary mathematics coaches and classroom teachers throughout the district, including planning and facilitating monthly, full-day coaches' meetings and site based instructional coaching for the mathematics coaches in their assigned cohorts of schools. The MISSLs' direct responsibility for coordinating the coaches' work, overseeing their meetings, and supporting ongoing professional learning made them integral to implementation success.

The MISSLs were recruited to help coordinate collaborative inquiry team work as part of monthly mathematics coaches' meetings and to provide evaluation data. Both MISSLs agreed to participate in the study but one withdrew after the September in-person meeting as he was re-assigned to work with the district's middle school mathematics educators. This left only one MISSL to support the elementary mathematics coaches and teachers across all 21 elementary schools and to support all four CITs in this study.

Working in the district for twenty years, the remaining MISSL brought experience as an elementary classroom teacher (4 years), school-based mathematics coach (11 years), and district-wide instructional leadership team member (5 years). The MISSL consented to participate in the study, including providing pre- and post-assessment data around C-MEFT and ISC perceptions and helping to facilitate the CITs throughout the study, ensuring time for this work and its alignment with and incorporation into other existing initiatives, mandates, and meetings. The MISSL's active involvement with the CITs' work was more limited than originally planned due to her expanded work load. She was unable to fit four, one-hour virtual meetings into her schedule each month, so she attended virtual meetings occasionally as her schedule allowed. She was also unable to be part of in-person meetings as she needed to facilitate other activities, such as instructional rounds, occurring simultaneously during the coaches' monthly meetings.

Measures and Instrumentation

Integral to this intervention's outcome evaluation are the constructs of critical colleagueship, collective mathematics efficacy for teaching (C-MEFT), and internal social capital (ISC; Figure 4.2; Figure 4.3). Collaborative interactions, participation and discourse norms, and focused activity and discussion are measurable attributes of critical colleagueship and serve as mediating variables, or outputs, in this study (van Es, 2012). The short-term outcomes of focus for this study are perceptions of C-MEFT and ISC. Changes in the dependent variables outcome expectancy and group competency measured C-MEFT perceptions (Goddard et al., 2000) and changes in the three dependent variables: structural capital, relational capital, and cognitive capital, measured ISC perceptions (Leana & Pil, 2006). Triangulation of quantitative data from pre- and post-survey responses and qualitative questionnaire data deepened overall understanding of these operationalized constructs and contributing factors within the study context (Creswell & Clark, 2011).

Construct	Operational Definition	Related Variables	Operational Definitions
Collective mathematics efficacy for teaching	An individual's beliefs about that groups' ability to work together to effectively teach mathematics and positively impact students' mathematics achievement (Bandura, 1997; Goddard, Hoy, & Woolfolk Hoy, 2000; Goddard et al., 2004; Moolenaar et al., 2012).	Task analysis (DV)	Beliefs about collective ability to promote meaningful mathematics learning within district classrooms (Goddard, Hoy, & Woolfolk Hoy, 2000).
		Group competency (DV)	Beliefs about the collective mathematics skills, methods, training, and expertise of educators in the district (Goddard, Hoy, & Woolfolk Hoy, 2000).
Internal Social Capital	The actual and potential resources embedded in and created by the structural, relational, and cognitive facets of existing relationships within an organization (Leana & Pil, 2006)	Structural capital (DV)	Perceptions of the value of information sharing among educators within the district (Leana & Pil, 2006).
		Relational capital (DV)	Perceptions of the level of collegial trust within the district (Leana & Pil, 2006).
		Cognitive capital (DV)	Perceptions of the degree of shared goals and vision present in the district (Leana & Pil, 2006).
Critical colleagueship	The degree to which a group of educators engage in discussions that support knowledge development and critical analysis of or reflection on existing practices and beliefs about mathematics teaching and learning (Lord, 1994; Kintz et al., 2015; van Es, 2012)	Collaborative interactions (MV)	The extent to which discussion related to mathematics teaching and learning involves multiple individuals, uses joint versus individual pronouns, and joins ideas and perspectives (van Es, 2012).
		Participation and discourse norms (MV)	The extent to discussion analyzing mathematics teaching and learning contains multiple versus single ideas and perspectives, includes supporting evidence for ideas, and elaborates upon or probes others' ideas (van Es, 2012).
		Focus of activity and discussion (MV)	The extent to which discussion of mathematics teaching and learning references specific artifacts or incidents from district classrooms versus general experience or ideas. (van Es, 2012).

Figure 4.2. Constructs, related variables and operational definitions.

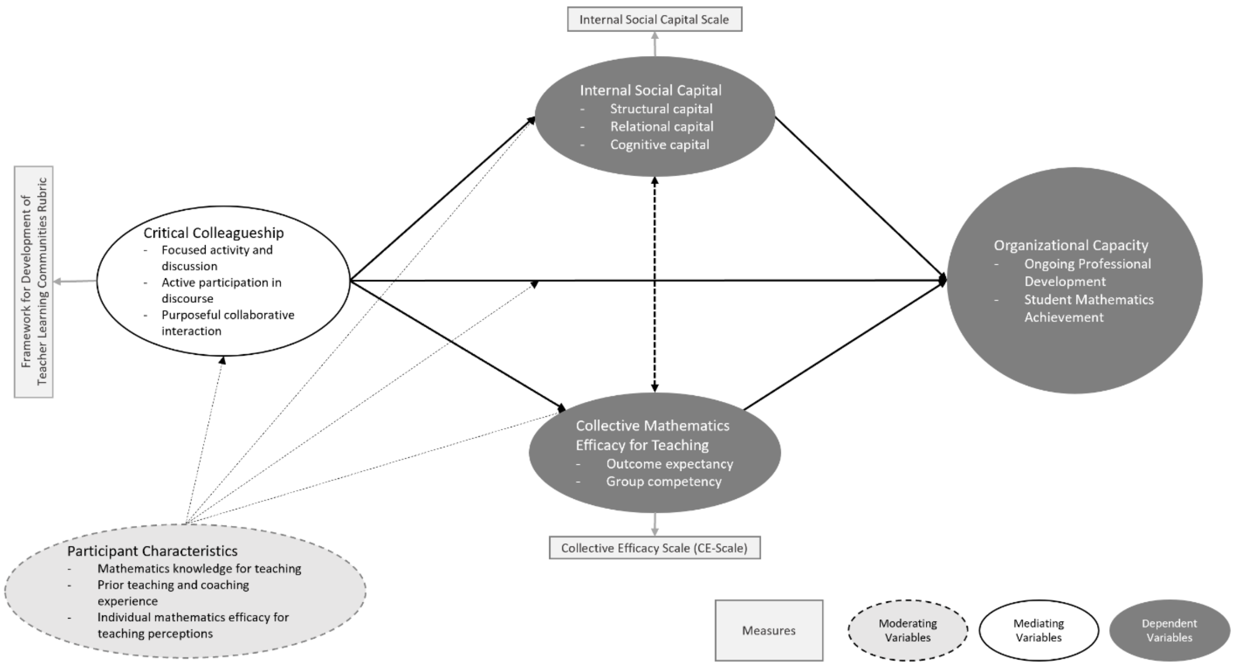


Figure 4.3. Theory of change diagram showing constructs, variables, and measures.

Critical colleagueship development. Critical colleagueship is defined as the degree to which a group of educators engage in discussions that support knowledge development and critical analysis of or reflection on existing practices and beliefs about mathematics teaching and learning (Kintz, Lane, Gotwals, & Cisterna, 2015; van Es, 2012). Three central features of teacher learning community conversations comprise this construct: (a) collaborative interactions, (b) participation and discourse norms, and (c) the focus of activity and discussion (Figure 4.2).

In this study, collaborative interactions were operationalized as the extent to which members actively engaged in discussions that recognized multiple points of view and promoted convergent thinking about mathematics teaching and learning. Participation and discourse norms were defined as the extent to which a group developed and enforced norms of interaction and discourse practices for analyzing mathematics teaching and learning that promoted reflective and inquiry-focused professional learning. Focus of activity and discussion was operationalized as the extent to which participants' topics of discussion were specific to mathematics teaching and learning in district classrooms (van Es., 2012). Transcripts from recordings of monthly online and in-person inquiry team discussions and archived online interactions were coded using van Es' (2012) three-stage rubric for community development to examine the extent of these critical colleagueship components within participant interactions. In this model, communities develop from a beginning stage, where interactions are focused on individual experiences, to a highly functioning stage, characterized by collective accountability and productive discourse (Appendix L). The rubric was deemed reliable in a study of a professional learning community structured around the examination of classroom mathematics instruction videos. Van Es and colleagues (2012) accompanied discussion analysis using this coding scheme with illustrative vignettes and had several individuals code a subset of transcripts, resulting in 85% inter-rater reliability. Additionally, van Es and colleagues (2012) examined discussions for confirming and disconfirming evidence of the three features in discussions from the early versus later sessions of their intervention to further validate the coding rubric.

Changes to collective mathematics efficacy for teaching (C-MEFT). A proximal outcome in this evaluation, C-MEFT refers to an individual's beliefs about their group's ability to work together to effectively teach mathematics and positively impact students' mathematics achievement (Bandura, 1997, Goddard et al., 2000; Goddard et al., 2004; Moolenaar et al., 2012). This construct is more than the sum of individual efficacy beliefs, and instead represents perceptions of group ability in relation to a specific teaching task within a given context. In other words, C-MEFT is an individual's conceptualization of the overall culture and environment of a school that influences both personal and organizational behavior (Ball, 1990; Goddard et al., 2004).

C-MEFT is comprised of two components: task analysis and group competency (Figure 4.2). In this study, task analysis referred to an individual's beliefs about the collective ability of district educators to promote meaningful mathematics learning within district classrooms (Goddard et al., 2000). The second component, group competency, referred to an individual's beliefs about the collective mathematics' skills, pedagogy, training, and knowledge of educators in the district (Goddard et a., 2000). Both task analysis and group competency perceptions involve an educator's analysis of the task of teaching mathematics within a given context, including the specific content, student characteristics, school context, and available resources. These perceptions are also influenced by moderating factors, including personal characteristics such as prior mathematics knowledge for teaching and job experience, as well as perceptions of individual mathematics efficacy for teaching. Changes to participants' C-MEFT perceptions were determined by comparing data from pre- and post-administration of an adapted version of Goddard et al.'s (2000) Collective Efficacy for Teaching Scale (CE-Scale; Appendix M).

Goddard and colleagues (2000) developed and tested the CE-Scale with teachers (n = 452) from 47 elementary schools in a large urban district in the Midwest. The instrument is comprised of twenty-one items across the two subcomponents of task analysis and group competency. Items targeting task analysis perceptions (n = 8) ask participants to select their level of agreement with statements such as: *The lack of instructional materials and supplies make teaching mathematics very difficult*. Items targeting group competency perceptions (n = 13) ask participants to select their level of agreement with statements such as: *Teachers in this school are well-prepared to teach mathematics* (Appendix M).

For this study, items were adapted from the original measure to be specific to mathematics (α = 0.85). Efficacy beliefs are context and task specific (Bandura, 1986, 1997;

Goddard et al., 2000; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998) making domain specific measures more predictive than decontextualized, omnibus measures (Bandura, 1986; Pajares, 1996). So, an original item such as: *Teachers here are confident they will be able to motivate their students* was adapted to: *Teachers here are confident they will be able to motivate their students* *in math*. Construct validity was established with correlational evidence for other social process constructs, such as collegial trust (Goddard et al., 2000). A positive correlation was found with individual teaching efficacy (r = .54; p<.01) and faculty trust in colleagues (r = .62, p<.01) (Hoy & Kupersmith, 1985; Hoy and Woolfolk, 1993), and no correlation was found to external pressures (r = .05) (Hoy & Sabo, 1998). Instrument reliability (a = .96) was determined through a pilot study with urban elementary educators (n = 452), a population similar to this study's participants.

Changes to perceptions of internal social capital. Internal social capital is an individual's perceptions of the value of the actual and potential resources embedded in and created by the structural, relational, and cognitive facets of existing relationships within an organization (Leana & Pil, 2006; Figure 4.2). Structural capital is defined as an individual's perceptions of the value of information sharing among educators within the school district. The frequency and flow of information and resources between individuals influences an organization's ability to "absorb and assimilate knowledge" and promotes "cooperation and mutual accountability" through situated learning (Leana & Pil, 2006, p. 353). This flow of resources is influenced by relational capital, or an individual's perceptions of the level of collegial trust and quality of relationships within the district (Leana & Pill, 2006). Strong relational capital supports collaboration and the transmission of information, which benefits both the school district itself, as well as the teachers who work there. Perceptions of associability, including the degree of shared goals and vision present in the district, held by individual teachers, comprise the cognitive capital of a school organization. Positive perceptions of cognitive capital decrease self-serving behaviors, promote more positive relationships, create a sense of shared responsibility, and support collective effort (Leana & Pil, 2006). Personal factors including knowledge, prior experience, and individual efficacy perceptions can moderate perceptions of internal social capital and need to be considered during analysis.

Leana and Pil's (2006) Internal Social Capital Scale (Appendix N) uses themes derived from qualitative data collected from focus group interviews and surveys of principals and teachers from urban districts around the U.S. to examine educators' perceptions of internal social capital value within a school or district (Figure 4.2). The structural capital subscale measures an individual's perceptions of information sharing among educators in the district and contains items such as: *Teachers engage in open and honest communication with one another*. The relational capital subscale measures an individual's perceptions of the quality of relationships within the district and includes items such as: *Teachers have confidence in one another in this district*. And items such as: *There is a commonality of purpose among teachers in this district,* measure cognitive capital, or an individual's perceptions of the degree of shared goals and vision.

Structural reliability for the Internal Social Capital Scale was determined using data collected from a pilot test in 88 urban schools in northeastern U.S. districts, with Cronbach alpha scores found to be $a = .90$ for the structural capital subscale, $a = .88$ for relational capital, and a = .93 for cognitive capital. Validity was determined through correlations between the components: trust and information sharing (a=.75, $p \leq .01$), shared vision and information sharing ($a = .63$, $p \leq .01$), and shared vision and trust (a=.69, $p \leq .01$).

Procedure

This goal-based intervention (Newcomer, Hatry, & Wholey, 2010) aligned to the Libertyville Public School District's mission to prepare all students for college and career success through collaborative team work and shared responsibility. This work entailed developing a new system of inter-school professional support networks to promote organizational capacity over time through authentic engagement in practice based, critical inquiry.

Prior to this intervention, the 20 full-time, school-based elementary mathematics coaches met monthly under the leadership of the district-wide elementary Mathematics Instruction School Support Liaisons (MISSLs) around an agenda set by the district's supervisor for mathematics teaching and learning and the MISSLs. The mathematics coaches' work at these meetings centered on district mathematics initiatives and curriculum, as well as the development of mathematics knowledge for teaching and instructional coaching strategies. This intervention extended this work by increasing opportunities for purposeful dialogue and structured collaborative inquiry with inter-school colleagues, as well as by providing coaches with more autonomy and ownership for their professional growth and empowering them to serve as instructional leaders who promote collective accountability within and between their schools.

Collaborative Inquiry Team (CIT) Development

Organized in four CITs (n = 4 or 6), the mathematics coaches, with guidance from the MISSL, collaboratively problem solved around self-identified goals aligned to district professional development priorities for mathematics instruction and student achievement: standards-based instruction, high-leverage instructional strategies, supporting English Learners, data-based decision making, and personalized student-centered instruction. Situating collaborative inquiry, aligned to existing policy mandates, within an autonomy-supportive environment develops individuals' sense of purpose, power, and control without adding demands to professional time and energy, increasing not only satisfaction and efficacy, but also productivity (Eyal & Roth, 2011; Faraj et al., 2015; Geijsel et al., 2003; Kahai, Jestire, & Huang, 2013; Minckler, 2014; Rock & Cox, 2012; Valli & Buese, 2007). To further alleviate barriers of time and space, while also allowing for the development of strong relationships (Anderson, 2008), the collaborative inquiry process in this intervention took place over six-months within a blended learning environment, that included: monthly in-person meetings (n=7), monthly synchronous, virtual meetings (n=5), and ongoing asynchronous work within the district's Google Classroom platform (see time line Figure 4.4). Throughout the process, the intervention design attended to both: (a) providing a structured inquiry process that supported autonomy, was embedded within daily practice, and distributed leadership; and (b) developing strong professional networks that spanned across schools, encouraged professional discourse around authentic problems of practice and encouraged shared accountability for both professional learning and student achievement.

Supporting both the inquiry process and inter-school professional support network development required attending to time for collaboration, the structure of the inquiry process, and development of relationships within and between teams. Tools and structures from Achieve New Jersey's *Collaborative Teams Toolkit* (State of New Jersey, 2015) were used and adapted to support team's inquiry process, including protocols for establishing a team goal and action plan and team norms and responsibilities (see Appendices H, I, O, and P for examples).

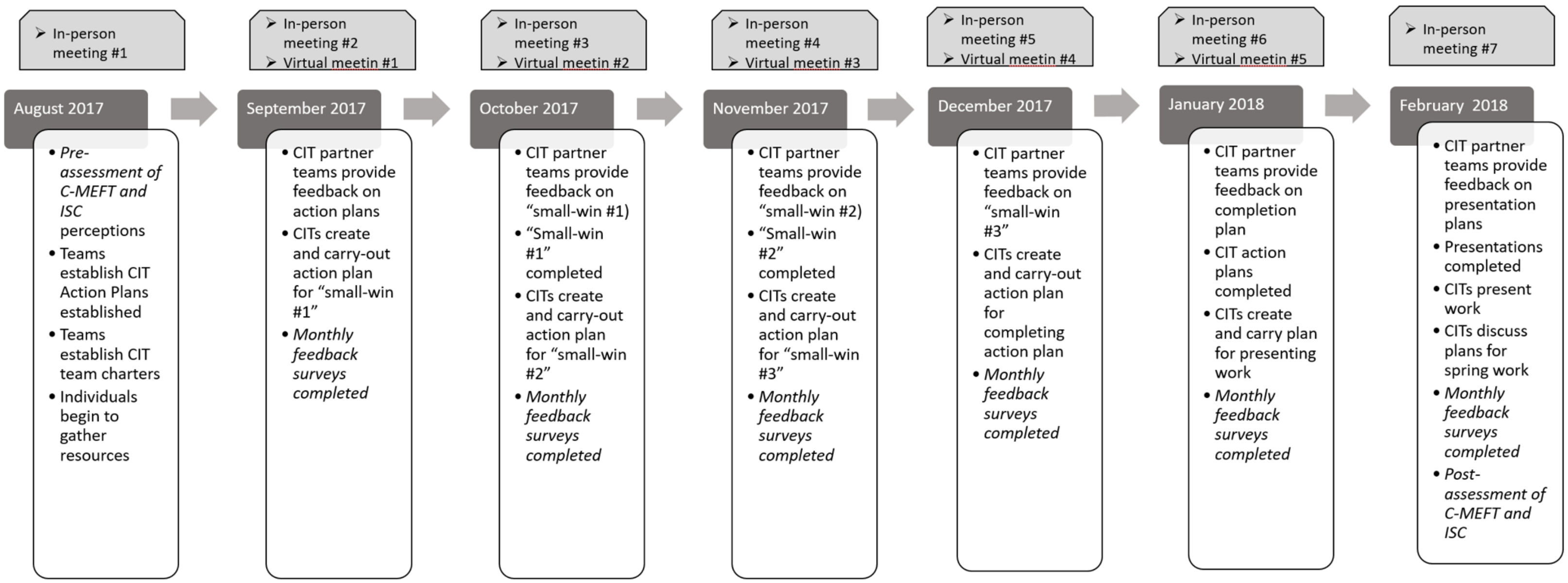


Figure 4.4. Intervention implementation timeline.

Establishing time for collaboration. Time for team collaboration was included in all three components of the blended learning environment: as part of monthly in-person coaches' meetings between August and February, through monthly virtual meetings using Google Hangout between September and January during the normal work day, and asynchronously through the district's Google Classroom platform and email server on a continuous basis as part of the coaches' daily work from late August 2017 until mid-February 2018 (Figure 4.4). Participants were not required to complete any work outside of their contracted work day and the inquiry work itself was aligned to their existing work priorities, including their School Improvement Plans and the district's Teaching and Learning 2016-2021 Strategic Plan for mathematics. Therefore, this intervention was designed not to add to coaches' existing work load, but instead to facilitate and strengthen that work and maximize its outcomes for all district educators and learners (Figure 4.1).

The initial plan was for teams to meet for three hours during each monthly, full day elementary mathematics coaches' meeting, with two teams meeting in the morning and two teams meeting in the afternoon with the other half of the day being spent working on district initiatives, such as common assessments. However, just prior to the start of the 2017-2018 school year, the district's director of curriculum and instruction decided instructional rounds needed to be part of each monthly meeting as well. As a result, the CITs were only able to meet in-person for seventy-five minutes each month. Initial planning had also called for each team to meet virtually for three hours each month. Teams were not able to find a three-hour time frame when they were all available, so it was agreed that teams would shorten these meetings to one-hour.

As a result, although teams were still scheduled to meet bi-monthly, the total time for the intervention meetings was cut by almost one-third, so the original agendas for these meetings were adjusted. Seeking to develop and strengthen social capital across district schools, the original plan was to pair up teams at each in-person meeting to increase communication and resource sharing (see Appendix Q). Though these pairings were an important element, it was determined that it was more critical for each CIT to have the full hour of both meeting times to work on its goal and team development. So, as figure 4.5 shows, cross team collaboration was eliminated from each meetings' agenda. Teams did still have an opportunity to share resources through Google classroom within their shared coaches' classroom space and drive. Teams were also provided time to share goals and progress with each other at the November in-person meeting and at the final in-person meeting in February.

	~~Individuals will provide feedback to partner team regarding CIT action plan & share resources as appropriate.~~	Individuals will: ~~Provide constructive feedback for the CIT Action Plan of their partner team using the comment tool within Google drive (due by partner team's virtual meeting): questions about focus or timeline & ideas for resources or action steps~~ Begin to gather data & resources specific to team goal to share at virtual meeting Communicate with team members as needed	Asynchronous work	Researcher will monitor asynchronous communications to collect critical colleagueship data
	Each team will: Provide individuals with an opportunity to share personal or professional "news" Share collaboration issues from asynchronous work & problem solve/adjust expectations as needed Review synchronous collaboration norms & logistics	Each team will: ~~Review feedback from partner team~~ Share gathered data and resources specific to their chosen goal Use this data to create a specific action plan for "small-win 1" Distribute workload by assigning specific tasks to individuals due at f2f meeting & next virtual meeting	Online synchronous meeting	Researcher will monitor recordings/transcripts from synchronous meetings to collect critical colleagueship data
September 2017	~~Teams will:~~ ~~Participate in a team building activity~~ ~~Share progress & struggles with partner team & provide constructive feedback to each other~~ Each team will: Share out collaboration issues from asynchronous and/or synchronous work Adjust norms & role expectations as needed	Each team will: Share data & resources gathered Discuss progress made on "small-win 1" Determine work still needed to be done to complete "small-win 1" & distribute remaining workload with deliverables Draft a plan for beginning work on "small-win 2" & update CIT Action Plan ~~Share updated CIT Action Plan with partner team (Google drive)~~ Schedule synch meeting for Oct.	Face-to-face meeting	Participants will provide feedback around system & team functionality using online Qualtrics survey Researcher will monitor recordings/transcripts from f2f meetings to collect critical colleagueship data

Figure 4.5. Sample monthly meeting agendas showing changes made as result of shortened meeting time allowance.

Structuring the inquiry process. To work efficiently and effectively, the CITs needed access to resources for both planning their job-embedded inquiry and for carrying out that plan.

In addition to time and space for collaboration, CITs needed support establishing a clear and attainable goal and realistic steps for achieving that goal within the six-month time frame.

The timeline for this inquiry work was as follows (see timeline Figure 4.4 and logic model Figure 4.1):

- August 2017: Each CIT determined their inquiry focus, developed an actionable goal, and created an action plan at two half-day, in-person meetings using district data and strategic plans from the district and schools. Protocols including a SMART Goal template, the Collaborative Inquiry Protocol: Consultancy on a Problem of Practice, and the Five Whys Tool for Root Cause Analysis (Appendix O) were provided as scaffolds for this process. Additional support came through the completion of the Collaborative Inquiry Team Plan template (Appendix H) that was shared with the researcher and MISSL for feedback and on-going modification as needed (see agenda details Appendix Q).
- September 2017 – January 2018: CITs used monthly in-person and virtual meeting time to share progress and resources, discuss ideas and dilemmas, and modify the action plan as needed. Each month, teams shared resources found and progress made, brainstormed solutions to arising issues, established specific next step goals ("small wins") and action plans for achieving those goals, and distributed the workload by assigning specific tasks to individuals. CIT members also collaborated and worked independently within the Google Classroom platform, using Google Drive to share resources and collaboratively create documents, spreadsheets, and presentations to support and coordinate their work.

Ongoing, asynchronous communication also took place through the district's email server (see agenda details Appendix Q).

- February 2018: For the final meeting, each CIT created a presentation to share and celebrate their inquiry work and its outcomes. Participants also developed a work plan for the remainder of the school year as support for ongoing professional learning around effective mathematics teaching and learning in the district.

Developing professional relationships. Effective collaboration requires clear articulation of individual accountability, norms for communication and collaboration, and development of collegial trust (Cosner, 2009; Thompson & MacDonald, 2005). Although 18 of the 20 coaches had worked in this capacity in the district for at least a year prior to the start of the study, their work together in past years had been limited to the scheduled time at their monthly elementary mathematics coaches' meetings. Collaboration at these meetings traditionally centered on completion of tasks assigned by district administrators and development of content and instructional coaching knowledge and skills. As a result, even though they knew each other, each coach, though part of a district established cohort, was working in isolation at their individual school, not as a part of a cohesive or coordinated team focused on district-wide capacity building. Increasing opportunities to interact in structured, purposeful problem-solving teams can support the development of trusting, collaborative relationships, a critical organizational resource for capacity building and change enactment (Cosner, 2009; Smith, 2005). This intervention worked to develop trust between team members by first establishing structures and expectations for honest communication, collective decision making, and conflict resolution and secondly by supporting the identification and development of inquiry goals based on shared needs and interests. These two steps are identified as vital for leveraging collective capacity and enacting change (DuFour, 2016; Goddard et al., 2000; Donohoo et al, 2018)

The process of strengthening professional relationships began at the first in-person meeting in August with the development of a team charter and continued throughout the six-month intervention (see Appendix Q for details), as follows:

- Each CIT created a team charter using a revised version of the CATME Smarter Teamwork's Team Charter template as a guide (Appendix I) to establish specific norms and role expectations for in-person meetings, virtual meetings, and asynchronous collaboration and communication. Tools including the RACI Roles and Responsibilities Matrix, 7 Norms for Collaboration, Forming Ground Rules, and Anderson's (2008) Asynchronous Communication Norms (Appendix P) scaffolded this process. Opportunities were provided at each team meeting for teams to review and modify the norms and roles developed within their charters.
- Each in-person meeting and each virtual meeting began with time for individuals to informally share personal news to allow individuals to get to know each other on a personal level and build trust between team members. This increased awareness of life experiences also helped build team cohesion and empathy, supporting the development of collective accountability and cooperation which helped teams overcome obstacles as they arose (Anderson, 2008).
- The final meeting (February 2018) provided time for the CITs to come together to share and celebrate accomplished work and to determine next steps for moving mathematics teaching and learning forward throughout the district.

Facilitating collaborative inquiry team work. Based on a social constructivist approach to knowledge development (Benbunan-Fich & Arbaugh, 2006), the mathematics coaches assumed the primary responsibility for enacting the inquiry process within their CITs, establishing their overall goal, the action plan for attaining that goal, and the group norms for their collaborative inquiry. This constructivist learning approach did not however eliminate the need for guidance and support from a knowledgeable facilitator, who could support learning by "encouraging open communication and affective expression and supporting group cohesion" (Caudle, 2013, p. 115). Reiser and Dempsey (2012) propose that high quality constructivist learning opportunities "require more support, more access to resources, more careful design and attention to detail, more process monitoring, and more carefully crafted guidance" (p. 48) than other types of learning. In the original design, the district's MISSL was to fill this facilitation role by serving as both *cheerleader* and *sheriff* (Booth, 2012; Fusco et al., 2011), to ensure teams adhered to their established CIT plan and team charter and to celebrate team successes, while still allowing the mathematics coaches themselves to lead the overall work. However, as explained earlier because one MISSL was re-assigned, doubling the work load of the remaining MISSL, she was unable to facilitate CIT meetings, leaving teams to work more autonomously than originally planned. The researcher did attend and support the work at all CIT meetings, creating the structure for the overall collaborative inquiry process, ensuring online resources remained organized and accessible, providing content information and instruction as needs arose, and evaluating the implementation process throughout the intervention making adjustments as needed. Regular attendance at all team meetings also allowed the researcher to communicate shared goals, issues, and "just-in-time" resources across teams. The researcher did not, however, take an active facilitation role in CIT meetings, knowing her presence in the district was only temporary and would not be a sustainable element of CIT work.

Data Collection

Evaluation data was collected regarding (a) the short-term outcomes of changes to perceptions of C-MEFT and internal social capital, (b) fidelity of the intervention output of increased critical colleagueship, and (c) fidelity of the implementation of the collaborative inquiry work.

Perceptions of C-MEFT and internal social capital. The 20 elementary mathematics coaches and the Mathematics Instruction School Support Liaison (MISSL) were recruited to complete the CE-Scale (Goddard et al., 2000; Appendix M) and Internal Social Capital Scale (Leana & Pil, 2006; Appendix N) prior to participation in the intervention and after the intervention was completed. The scale was administrated electronically during the first in-person meeting of the intervention in late August 2017 and again at the final in-person meeting in February 2018 using the Qualtrics online survey platform (https://www.qualtrics.com/), licensed through Johns Hopkins University.

Fidelity of intervention: Development of critical colleagueship. Engagement in critical colleagueship, both in-person and online, was the anticipated output for this intervention. Inquiry team discussions involving the mathematics coaches and MISSL at the monthly, in-person meetings were recorded and then transcribed for analysis. Monthly synchronous team meetings involving the mathematics coaches and MISSL, held using Google hangouts, were recorded audially and archived on the researchers' computer, and then transcribed for analysis. Additionally, ongoing email conversations between participants and comments made on shared documents by mathematics coaches and the MISSL were archived monthly for analysis (Appendix G).

Fidelity of implementation: Collaborative inquiry team work. Levels of participation and engagement in the inquiry team process and utilization of intervention structures and systems determined fidelity of implementation. A variety of data sources supported this part of the process evaluation. Attendance records for monthly in-person and virtual meetings, frequency tabulations for asynchronous online communications, and monthly feedback survey data from the coaches supported an analysis of actual participation and engagement by individuals and teams in the collaborative inquiry process. Monthly feedback surveys (Appendix J) completed by the coaches, observations of online work interactions between members of the inquiry teams, and rates of participation in different intervention components (in-person meetings, virtual meetings, and asynchronous collaboration) supported an analysis to identify which intervention structures and systems were used and valued by participants during the collaborative inquiry process (Appendix G).

Data Analysis

Data analysis of this intervention involved both quantitative and qualitative techniques to examine the development of critical colleagueship within inquiry teams, changes to participants' perceptions of collective mathematics efficacy for teaching (C-MEFT) and internal social capital (ISC), and the processes and structures of the intervention design itself. Data analysis also examined connections between these factors, as well as the fidelity of the intervention and its implementation.

Development of critical colleagueship. Using each conversation as the unit of analysis, archived transcripts from in-person and virtual meetings and from text based online communications were analyzed using a priori codes based on van Es' (2012) three-stage rubric for community development, specific to the three components of critical colleagueship: collaborative interactions, discourse norms, and focus of activity or discussion (Appendix L).

Specific coding was completed as follows:

(a) Collaborative interactions were determined by the degree to which discussions involved multiple individuals, used of joint versus individual pronouns, and the joined ideas and perspectives about mathematics teaching and learning. Discussions were labeled *beginning* if "participant talk was one-sided or egocentric" and *high-functioning* if "participants listened to each other and pursued each other's ideas, tried to understand each other's ideas, and offered support to others" (van Es, 2012, p. 186).

(b) Discourse norms were determined by the degree to which discussion content contained single versus multiple ideas and perspectives about mathematics teaching and learning, including supportive evidence for ideas, and elaboration upon or probing of others' ideas. Discussions were labeled *beginning* if "only one perspective was represented" and *high-functioning* if "different ideas and perspectives were raised and consistently discussed" (van Es, 2012, p. 186).

(c) And the degree of focus of activity or discussion was determined by content that referenced specific mathematics teaching and learning artifacts or incidents from classrooms versus general experience or ideas. For example, specificity such as, *In the video of your lesson, Theo seems to be confusing two methods, the traditional algorithm and the partial quotients method,* versus generalizations such as, *Students always seem to have trouble with long division*. Discussions were labeled *beginning* if

> “analysis was general in nature and may have addressed a variety of topics peripheral to classroom [mathematics] learning” and *high-functioning* if “analysis of student thinking and learning informed analysis of [mathematics] teaching and future pedagogical decisions in participants’ classrooms” (van Es, 2012, p. 186).

Conversation analyses were organized by date and team with the summative goal of determining changes over time for each component within each team. These data were then triangulated with C-MEFT and ISC perceptions data to answer research questions one and two that consider the influence of critical colleagueship on perceptions of these constructs and related variables. Additionally, the data was triangulated, both formatively and summatively, with data related to participant engagement and system/structure usage during the process evaluation to answer research questions five and six that consider the influence of levels of engagement and program structures and systems on the development of critical colleagueship (see Appendix G).

Changed perceptions of collective mathematics efficacy for teaching (C-MEFT). Statistical analysis of pre-and post-administration of the Collective Efficacy for Teaching Scale (CE-Scale) determined changes to participants’ C-MEFT perceptions. The CE-Scale is a seven-point Likert scale developed to analyze teachers’ C-MEFT perceptions (Appendix M). The scale ranges from strongly disagree (1) to strongly agree (7), with negatively worded items being reverse coded for analysis. Teachers perceptions of both task analysis and group competency are determined by averaging scores from related items. A score of one indicates a negative perception, a two or three indicates a moderately negative perception, a four indicates a moderate perception, a five or six indicates a moderately positive perception, and a seven indicates a positive perception.

Using the individual as the unit of analysis, pre- and post-administration data was explored using descriptive statistics and a paired samples t-test was used to determine whether statistically significant changes occurred for any individuals as a result of intervention participation. Data of changed perceptions was also be disaggregated by team and triangulated with critical colleagueship data to answer research question one, by examining the influence of critical colleagueship on perceptions of C-MEFT.

Changed perceptions of internal social capital. Comparing data from pre- and post-administration of Leana and Pil's (2006) Internal Social Capital Scale determined changes to participants' perceptions of internal social capital within the district. The Internal Social Capital Scale (Appendix N) is a seven-point Likert scale ranging from strongly disagree (1) to strongly agree (9). It contains eighteen items, six from each of its three components: structural capital, relational capital, and cognitive capital. Educators' perceptions of each component are determined by averaging scores from related items. A score of one indicates a negative perception, a two or three indicates a moderately negative perception, a four indicates a moderate perception, a five or six indicates a moderately positive perception, and a seven indicates a positive perception of internal social capital within the district.

Using the individual as the unit of analysis, pre- and post-administration data was explored using descriptive statistics and a paired samples t-test determined if statistically significant changes occurred for any individuals. Data of changed perceptions was also disaggregated by team and triangulated with critical colleagueship data to answer research question two, by examining the influence of critical colleagueship on perceptions of internal social capital (Appendix G).

Use of structures and systems within blended learning environment. Data gathered related to the use of specific online tools and systems designed to support collaborative inquiry and the development of critical colleagueship was used summatively to answer research question four and formatively to adjust the intervention design and monitor fidelity of implementation. Monthly feedback survey responses related to usage of various Google Classroom tools (see Appendix J) was analyzed using descriptive statistics, as were frequency tabulations for participation rates in each intervention component (in-person meetings, video meetings, and asynchronous online collaboration). Tool and system usage was tracked over time and disaggregated by collaborative inquiry team (CIT). This disaggregated usage data was also triangulated with critical colleagueship data and vignettes from meeting transcripts to provide a clearer understanding of implementation fidelity and the connections between the implementation design and the output of critical colleagueship within CITs (Appendix G).

Engagement in collaborative inquiry team work. Active engagement in the collaborative inquiry process by all mathematics coaches was a key indicator of implementation fidelity. Without authentic engagement, critical colleagueship likely would not develop and perceptions of C-MEFT and ISC would not likely change. Monthly survey responses related to individual and team participation (Appendix J), attendance at team meetings, and tabulations of contributions to asynchronous interactions were examined using descriptive statistics to determine individual engagement in the intervention. These data were used formatively to adjust the intervention design to better meet individual needs and prevent attrition. Engagement data was also disaggregated by team and month and triangulated with critical colleagueship data to evaluate implementation fidelity and answer research question five: How did differing levels of engagement influence critical colleagueship development within teams? (Appendix G).

Evaluating implementation and intervention fidelity both formatively and summatively, as described in the Evaluation Matrix (Appendix G), not only supported the refinement of the intervention itself during implementation, but also supported validation of findings from the outcome evaluation and helped explain unanticipated findings and determine if they were attributable to the intervention itself or its implementation, providing guidance for future iterations (Dusenbury et al., 2003; Saunders et al., 2005).

Chapter 5: Findings and Discussion

The evaluation of many professional development designs focuses on knowledge acquisition and strategy implementation outcomes for individuals (Abrami et al., 2011; Linder et al., 2013; Wilson & Berne, 1999). This intervention's evaluation instead used social cognitive and social capital lenses (Bandura, 1986; Minckler, 2012) to examine the influence of critical colleagueship development on elementary mathematics coaches' perceptions of collective mathematics efficacy for teaching (C-MEFT) and internal social capital value (ISC). Lord's (1994) notion of critical colleagueship within professional communities and Bandura's (1986) social cognitive theory both support the premise that collaboration, especially between individuals with varying life experiences and perspectives, supports the development of knowledge and confidence, including C-MEFT. Collaboration with inter-school colleagues also supports development of professional relationships that have the breadth and depth needed to diffuse information and resources throughout an organization (Lord, 1994). It is these efficient resource exchanges that enhance ISC value and ultimately result in improved organizational capacity for both ongoing professional learning and student achievement (Minckler, 2014).

Effective professional learning communities, whether in a traditional face-to-face environment or the blended learning environment used in this intervention, cannot simply be designed but instead must be created through the careful cultivation of participant engagement that balances structure and autonomy (Thompson & MacDonald, 2005); a balance this intervention sought to develop and maintain. The following chapter discusses the findings from the outcome evaluation of the intervention, the process evaluation of implementation and intervention fidelity, and connections between fidelity, outputs, and outcomes with suggestions for future iterations and professional development design. Specifically, discussion of intervention outcomes focuses on the influence of critical colleagueship development on the elementary mathematics coaches' perceptions of both C-MEFT and ISC. And discussion of the process evaluation examines formative and summative data related to, (a) the impact of engagement in structured collaborative inquiry within a blended learning environment over time on the degree of critical colleagueship development within collaborative inquiry teams (CITs), (b) the influence of blended learning structures and systems on critical colleagueship development within CITs, and (c) the impact of different levels of engagement within CITs on critical colleagueship development.

Process of Implementation

This six-month study from August 2017 through February 2018 involved the elementary mathematics coaches *(n* = 20) and one elementary Mathematics Instruction School Support Liaison (MISSL) from the Libertyville School District, an urban district in New England. The coaches met bi-monthly (once in-person and once virtually) in small teams of either four or six members to develop and work on self-identified collaborative inquiry projects focused on supporting mathematics teaching and learning across the districts' 21 elementary schools. The following is a description of their structured inquiry process, that included establishing team structures and expectations, establishing measurable and actionable goals, and utilizing online tools to support ongoing team collaboration.

Establishing Team Structures and Expectations

The study launched as part of two full-day, district sponsored, professional development days for the elementary mathematics coaches in August 2017, immediately prior to the beginning of the school year. The focus for the first in-person meeting centered on establishing structures and expectations for collaborative inquiry work. The session started with participants engaging in discussions around an open mathematics task (see Figure 5.1). First the coaches came up with an individual answer to the problem, then shared/compared answers and approaches, and finally connected this activity to their work as instructional leaders. This task-based discussion was followed by an examination of differences between working as a group and working as a team, focusing on three key shifts: decentralized leadership, autonomy, and interdependence (DuFour, 2016). This conversation built upon district led work conducted during the previous school year that sought to shift the mathematics coaches' focus from school-based to district-wide collective accountability for students' mathematics achievement.

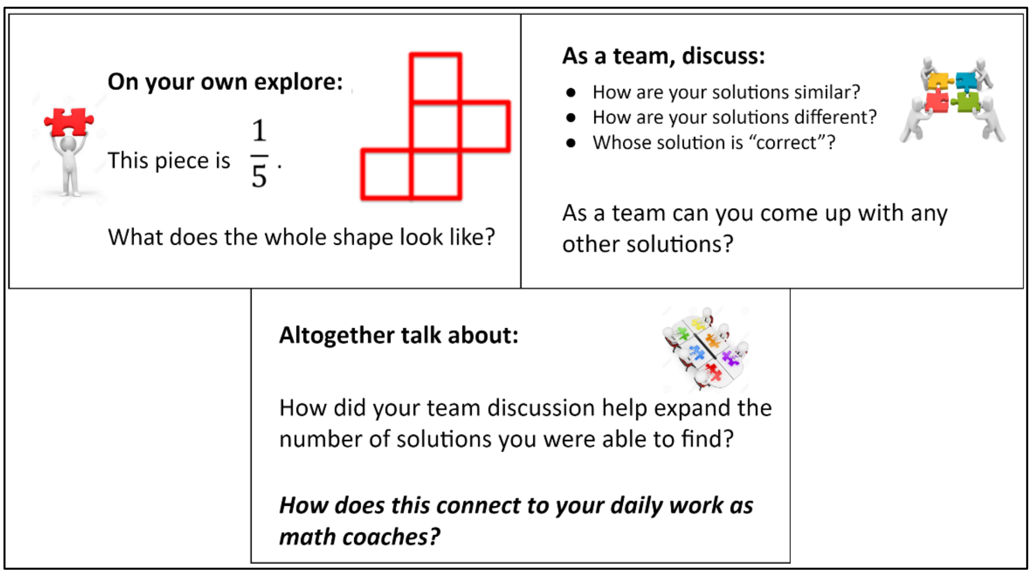


Figure 5.1. Screenshots of presentation slides structuring discussion of an open-ended task as an analogy for team work collaboration.

Establishing clear norms and expectations for collaboration, mutual support, and accountability, as well as establishing a specific work focus, are vital for successful development of interdependence (Cosner, 2009; DuFour, 2016; Thompson & MacDonald, 2005). Therefore, this discussion of working as a team was followed by time for CITs to begin developing structures and systems for their collaborative inquiry work by creating a team charter for collaborative norms and responsibilities and determining their collaborative inquiry focus. After being introduced to resources the researcher had organized within their mathematics coaches Google classroom (see Figure 5.2), each team began by creating a team charter using a modified version of the CATME Smarter Teamwork's Team Charter template (Appendix H) to establish norms, role expectations, and communication guidelines. Each CIT talked through preferred contact information, perceived personal strengths and weaknesses related to team work, and potential team work barriers, such as lack of attendance or unequally distributed workloads. CITs also established roles and norms to be used at subsequent meetings.

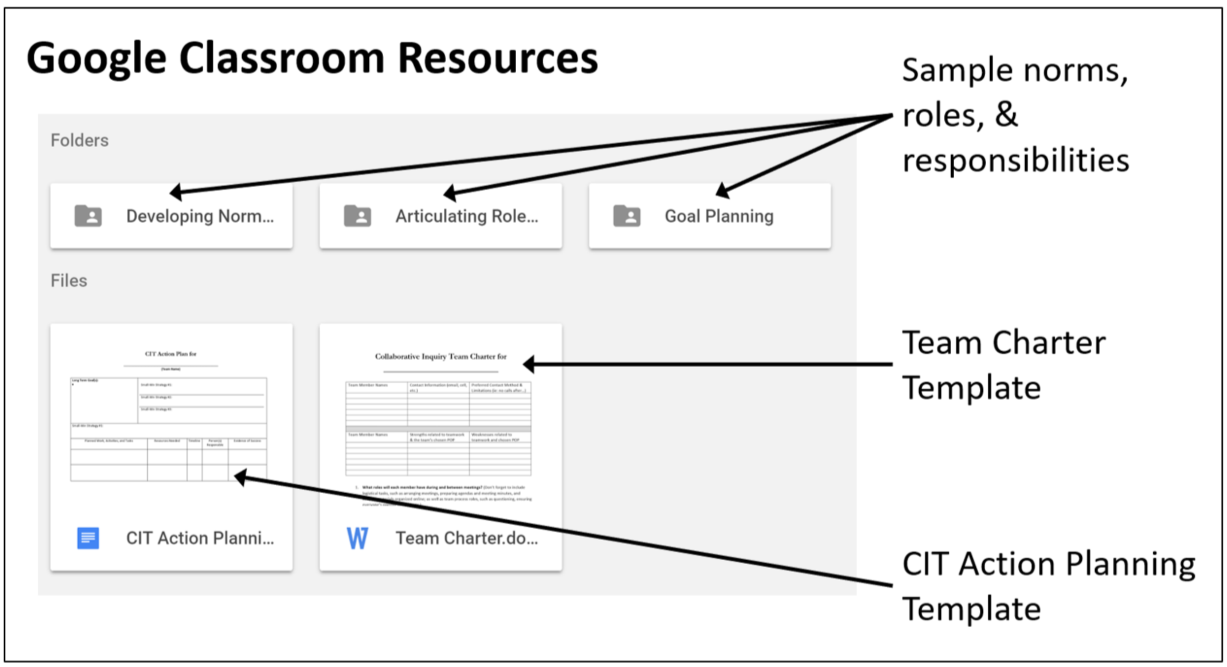


Figure 5.2. Screenshot of presentation slide introducing CITs to team planning resources within their shared Google drive space.

Not all teams perceived developing collaborative norms as necessary or valuable work. One example is team Y. During this first meeting, the team chose to spend most of its time defining team member roles and creating a rotating schedule for these roles for the course of the study (five in-person and five virtual meetings; see Figure 5.3). Instead of discussing individuals' perceived strengths and challenges related to the work, they asked each person to fill in this information independently. They also stated they did not feel it was necessary to discuss potential team work process issues, such as acceptable or unacceptable excuses for missing a meeting or expectations regarding team members' ideas, interactions with the team, cooperation, and attitudes. When asked to explain this decision, one member stated, *we're all adults and professionals and expect everyone will behave that way*. Not engaging in collaborative discussion and disclosure at the initial meeting appears to have impeded their work the next day when they attempted to determine a focus and plan for their inquiry work, as described next.

What roles will each member have during and between meetings? (Don't forget to include logistical tasks, such as arranging meetings, preparing agendas and meeting minutes, and keeping materials organized online; as well as team process roles, such as questioning, ensuring everyone's opinion is heard, etc.)

Rotate Roles: Keep roles for the month and then rotate to the next

1. **Facilitator:** creates agenda with outcomes
2. **Resource Manager:** gathers materials and communicates about meeting, creates hangout, put materials in Team Y folder
3. **Recorder:** Records Minutes and next steps/deliverables
4. **Time Keeper:** keeps the group on track
5. **Process Observer:** Provide feedback to team members individually and collectively on the team's operations, particularly on how well the team adhered to its Team Charter agreements and where it veered from them. The process observer also might engage members in a discussion of their individual and collective behaviors rather than being the person to provide the feedback.
6. **Alternate**

	Sep	Oct	Nov	Dec	Jan	Feb
Y1	1	2	3	4	5	6
Y2	2	3	4	5	6	1
Y3	3	4	5	6	1	2
Y4	4	5	6	1	2	3
Y5	5	6	1	2	3	4
Y6	6	1	2	3	4	5

Figure 5.3. A screenshot of the portion of team Y's team charter for collaborative norms showing the roles and responsibilities the team established and their rotating schedule for meetings across the six-month study.

Establishing Measurable and Actionable Goals

Having established some initial guidelines and expectations for their collaborative work, during the second consecutive professional development day, CITs began what Crow and Hirsh (2015) identify as the *learning team cycle of continuous improvement*, by determining a goal for their collaborative inquiry process, building upon work done in June 2017. During this earlier meeting, CITs had completed stage one of Crow and Hirsh's (2015) learning team cycle. They examined student achievement and instructional rounds data from the previous school year and identified a specific problem, appropriate and worthy of collaborative inquiry, having discussed shared issues across the school improvement plan (SIP) from each of their schools (see table 4.1).

With their chosen foci in mind, teams moved to stage two of Crow and Hirsh's (2015) learning team cycle, determining a SMART goal for their collaborative inquiry work, a goal that is specific, measurable, attainable, relevant, and timely. Establishing SMART goals is a process familiar to the coaches, as it is a regular component of their work as members of their schools' instructional leadership teams. Three of the teams (W, X, and Z) established a SMART goal (see table 5.1) as well as ideas for initial work to be done independently before their next meeting in September. An important note is that, with the exception of team X, none of the teams initially had a plan for measuring success on their SMART goal. Not having a plan for collecting inquiry work data became a major theme at subsequent discussions, as did clarifying the meaning of terms within their goals, especially the term engagement.

Team Y did not leave the first meeting in August with a SMART goal or positive feelings about their collaborative work. One member approached the MISSL at the end of the day stating:

> *I don't know how this is possibly going to work. No one is listening to each other and there are two people taking over the conversation who do not seem to respect each other's ideas. Every time I tried to talk I was interrupted. I was really excited to get to work with other coaches, but right now I'm feeling like I just want to work alone at my school. (Y1)*

Table 5.1

Areas of Focus and SMART Goals for Collaborative Inquiry Written on CIT Action Plans

	Initial Area of Focus	SMART Goal
Team W	Supporting teachers' ability to increase student-to-student discourse, authentic student engagement, and cognitive demand within a blended learning model [station rotation involving computer, small group, and independent practice].	By February 2018, based on weekly observation notes, we will see an increase in collaborative groups engaged in authentic mathematics conversations, during blended learning in the classrooms we support.
Team X	Supporting student-to-student engagement in problem solving contexts by helping teachers plan for productive struggle and perseverance.	By February 2018, we will see an increase in the percentage of students at the engagement level based on Schlechty's Levels of Classroom Engagement (www.schlechtycenter.org).
Team Y	Supporting teachers' incorporation of higher level DOK questioning and tasks into instruction.	By February 2018, we will see an increase of students communicating reasoning and responding to others around rigorous tasks in the classrooms we support.
Team Z	Using data and standards to purposely support mathematics instructional planning.	By February 2018, there will be an increase in opportunities for student engagement during the math block in the classrooms we support.

*Note: Team Y's SMART Goal was determined during the September meeting.

Two underlying factors may explain these initial concerns. First, as mentioned team Y did not take time during the first meeting day to talk through potential process issues or to share personal strengths and challenges. Second, team Y had two members who were new coaches, one who had been a classroom teacher in the district for 20 years and one who was new to the district after a move from another state. As a result, these two individuals had not worked with the other coaches before and had not been part of the discussion around the different SIPs last June. Both of these factors, not having talked through potential collaboration issues and having new team members, have been found to negatively influence trust, or the belief that individuals will make good-faith efforts, honor commitments, and not take advantage of others (Cosner, 2009). Trust is a precondition for cooperative behavior, interdependence, and group effectiveness in that it is vital for team members to balance individual and collective needs and ideas and to support collaborative and productive discourse (Anderson, 2008; Nelson et al., 2008; Tschannen-Moran & Gareis, 2015).

To help promote trust and success at the next meeting, the MISSL met with team members individually prior to the September meeting, providing them each with an opportunity to voice concerns and reiterate goals, and to reflect on the influence their own actions had on the development of a collaborative learning community. The MISSL also actively facilitated their September meeting, with a goal of reviewing their team charter and developing specific norms and structures to support their teamwork moving forward. These additional structures and systems positively influenced the coaches' subsequent work and are evidence of Anderson's (2008) proposition that

> The biggest problem for any team is the assumption that you can put people together to work on a task, and they will automatically become a team and know how to work together... The trick is to put the effort into the process side of teaming and teaching. (p. 468)

Online Tool Use for Team Collaboration

After the two initial meetings in August, the CIT's collaborative inquiry work progressed through the final three stages of Crow and Hirsh's (2015) learning team cycle: developing a plan, putting the plan into action, and refining practice, both synchronously at monthly in-person and virtual meetings and asynchronously as coaches worked from individual school sites. With team members working from different school locations, having a shared and easily accessible online platform to share resources and communicate regularly was critical for collaborative inquiry success (Anderson, 2008; Thompson et al., 2011). The Libertyville School District had introduced Google classroom and the G-Suite for Education tools to the elementary mathematics coaches during the 2015-2016 school year and promoted its use as support for both intra- and inter-school collaboration throughout the 2016-2017 school year. After learning from an October 2016 poll, conducted by a district technology specialist, that few (12%) of the elementary mathematics coaches were using the G-Suite for Education tools for collaboration, the MISSLs incorporated the elementary mathematics coaches' Google classroom into each of the monthly coaches' meetings during the 2016-2017 school year. This included housing all meeting related materials in a shared Google drive, providing links to agendas and resources within the classroom communication stream, and having coaches complete a Google forms survey at the end of each meeting to provide feedback, a link to which was set up as an assignment in their Google classroom. As a result of this practice and exposure to the different features and functions of the G-Suite for Education tools, 31% of the coaches stated they were comfortable using Google classroom at the end of the 2016-2017 school year. To support this district initiative and incorporate the CIT work into their daily, school-based practice, participants were supported in their use of Google classroom and the G-Suite for Education tools throughout the intervention by the researcher and the MISSL.

Work with the G-Suite for Education tools began with each CIT successfully creating their own Google classroom at the first August meeting day. Teams used this space to share links to resources, post links to monthly Google hangout meetings, and communicate key information.

The MISSL and the researcher also used the CITs' classrooms to share links to resources, post announcements, and post links to monthly feedback surveys. In addition to the communication stream in their classrooms, team members also communicated through email and text messaging. The prevalence of texting as a form of team communication was not anticipated, so although participants made the researcher aware they were using this modality, these conversations were not monitored or evaluated as part of the study. The degree to which each team used different G-Suite for Education tools and the perceived value of these tools for their CIT work are discussed in the following section.

Findings

The embedded, mixed methods design [QUAN(+qual)] of this study allowed for simultaneous collection and analysis of quantitative and qualitative data within a largely quantitative design to enhance overall interpretation and understanding of both outcomes and process (Creswell & Clark, 2011). Quantitative data from pre- and post-test surveys was used to determine whether changes occurred to participants' perceptions of collective mathematics efficacy for teaching (C-MEFT) and internal social capital (ISC), the focus of the outcome evaluation. And triangulation of additional quantitative data and qualitative data from monthly feedback surveys, conversation analyses, and other participant interactions was used to determine whether changes to C-MEFT and ISC perceptions were attributable to the development of critical colleagueship and overall research design elements.

Examining Outcomes

This study's treatment theory posits that regular engagement in structured collaborative inquiry connected to daily practice promotes critical colleagueship among inter-school colleagues leading to more positive perceptions of C-MEFT and ISC. Once in place, positive C-

MEFT and ISC perceptions amongst district educators support sustainable professional growth for district coaches and teachers, student achievement, and overall organizational capacity development (Andrews & Lewis, 2004; Booth, 2012; Bryk, Camburn, & Louis, 1999; Cosner, 2009; Geijsel et al., 2003; Kintz, Lane, Gotwals, & Cisterna 2015; Minckler, 2014; Thompson & MacDonald, 2005; Vavasseur & MacGregor, 2008). The short-term, proximal outcomes of changed C-MEFT and ISC perceptions were the outcome evaluation focus for this six-month intervention, given that organizational capacity development would not likely be evident in this short time frame. Specifically, the outcome evaluation of this study took an observational approach to examine connections (Leviton & Lipsey, 2007) between changes in individual's C-MEFT and ISC perceptions and the development of critical colleagueship within collaborative inquiry teams (CITs).

Quantitative analysis process. The goal of data analysis is to move from raw data to meaningful understanding (Lochmiller & Lester, 2017; O'Leary, 2004). Two types of quantitative analyses were used in this evaluation: inferential statistics to determine potential relationships and descriptive statistics to increase familiarity with the data (Lochmiller & Lester, 2017). A paired-sample t-test was conducted to examine both C-MEFT and ISC perceptions, to compare scores from this single, participant group across time to determine whether a significant change to these single continuous dependent variables occurred. Descriptive statistics were then calculated for the dataset to determine frequencies, patterns, and trends; including measures of central tendency and variability.

Data triangulation. The observational nature of the one-group, pre-test-post-test design of this study has limited statistical power to determine causal relationships. The lack of a control group and the small number of participants (n=21) produce numerous potential threats to both internal and statistical conclusion validity (Shadish et al., 2002). Recognizing this, a larger embedded, mixed methods design was employed to provide additional data sources and allow for data triangulation to support interpretation and help explain plausible patterns of relationships between engagement, critical colleagueship development and C-MEFT perceptions, correlations that could not be determined statistically due to the small number of participants (see Appendix G; Creswell & Clark, 2011; Lochmiller & Lester, 2011; Rossi et al., 2004).

Changes to perceptions of collective mathematics efficacy for teaching (C-MEFT). A dependent variable of this study, C-MEFT is defined as an individual's beliefs about their group's ability to work together to effectively teach mathematics and positively impact students' mathematics achievement in terms of both group competency and task analysis (Bandura, 1997; Goddard et al., 2000; Goddard et al., 2004; Moolenaar et al., 2012; see Figure 4.2 for a description of related variables). In this study, the C-MEFT perceptions of the 20 elementary mathematics coaches and the elementary MISSL were measured using Goddard et al.'s (2000) Collective Efficacy for Teaching (CE) Scale (see Appendix M). CE-Scale items reflect perceptions of both the collective teaching knowledge and expertise (group competency) and the collective ability to overcome external factors to promote meaningful mathematics learning (task analysis). Strong agreement (M=7 on the 7-point scale) with item statements thus reflect high or strong efficacy perceptions and strong disagreement ($1.00 \leq M \leq 1.99$ on the 7-point scale) reflects low or weak efficacy perceptions (Goddard et al., 2000). Using the Qualtrics online survey platform (https://www.qualtrics.com/), all 21 participants completed the CE-Scale twice, once at the beginning of the first professional development day in August 2017 and again at the end of the final session in February 2018.

Describing the data. After downloading and cleaning the data using Microsoft Excel, descriptive statistics were run to examine the distribution of scores in terms of patterns, trends, and frequencies. Overall (see Table 5.2) and when disaggregated by team (see Figure 5.4), group competency and task analysis perceptions of study participants remained average ($4.00 \leq M \leq 4.99$ on the 7-point scale) throughout the study (GC pre: *M*=4.18, *SD*=0.81; GC post: *M*=4.55, *SD*=0.63; TA pre: *M*=4.39, *SD*=0.71; TA post: *M*=4.69, *SD*=0.64). The one exception was the MISSL, whose task analysis perceptions remained moderately strong throughout (pre: *M*=5.10, *SD*=1.60; post: *M*=5.60, *SD*=1.90). These small changes to C-MEFT perceptions were expected as it is a relatively stability characteristic (Bandura, 1997). However, because C-MEFT perceptions influence individuals' effort and persistence, even the small positive increase found in this study can have a large impact on student achievement, as a one-unit increase has been found to result in a 40% (8.62 point) increase in student achievement (Goddard et al., 2000).

Table 5.2

Descriptive Statistics: Collective Mathematics Efficacy for Teaching Perceptions (n=21)

Variable	Administration	*M* (*SD*)	Median	Min	Max
Group Competency	Pre	4.18 (0.81)	4.09	2.73	5.91
	Post	4.55 (0.63)	4.64	3.27	5.36
Task Analysis	Pre	4.39 (0.71)	4.30	3.30	5.80
	Post	4.69 (0.64)	4.50	3.40	5.60

Note. Responses based on a seven-point Likert scale ranging from strongly disagree (1) to strongly agree (7).

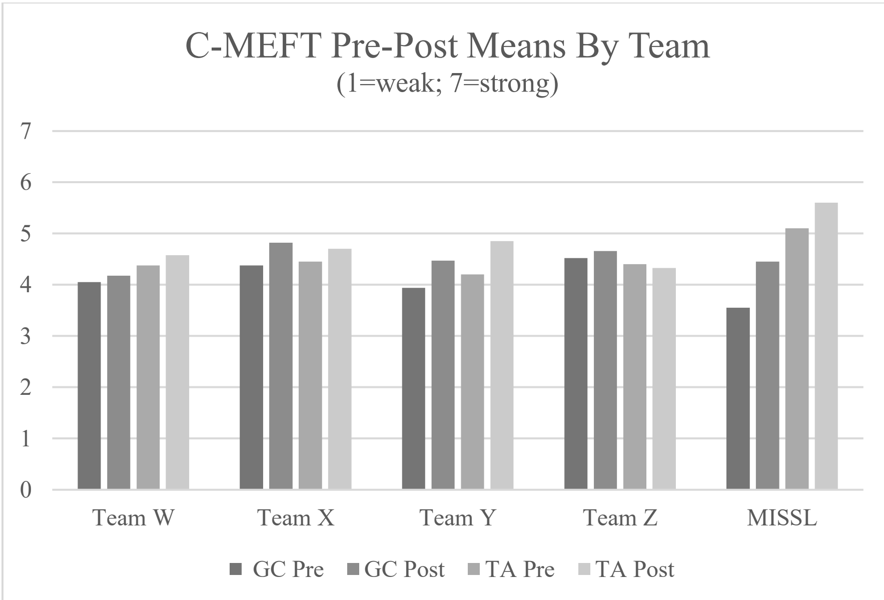


Figure 5.4. Pre-post means for C-MEFT perceptions disaggregated by team. GC = group competency subscale. TA = task analysis subscale. See figure 4.2 for descriptions of subscales.

Determining significance. To determine whether a significant change in perceptions had occurred, a paired-samples t-test for means was conducted comparing pre- and post-intervention perceptions of C-MEFT using Microsoft Excel (Table 5.3). A statistically significant change was found for participants' perceptions of both components of C-MEFT: group competency [$t(20) = 2.17$, $p = .04$] and task analysis [$t(20) = 2.14$, $p = .04$]. This indicates that, collectively, participants' perceptions of both the collective skills and knowledge of the educators across the district (group competency) and their perceptions of the collective capacity to promote students' mathematics achievement (task analysis) became more positive over the course of the study.

Table 5.3

Paired Two Sample t-Test for Pre- and Post-Intervention Means: Collective Mathematics Efficacy for Teaching (MEFT) Perceptions (n=21)

Variable	Administration	M (SD)	t	p
Group Competency	Pre	4.18 (.65)	2.17	0.04
	Post	4.55 (.39)		
Task Analysis	Pre	4.39 (.51)	2.14	0.04
	Post	4.69 (.40)		

Note. Responses based on a seven-point Likert scale ranging from strongly disagree (1) to strongly agree (7).

Changes to perceptions of internal social capital (ISC). A second dependent variable in this study, ISC refers to an individual's perceptions of the actual and potential resources embedded in and created by existing relationships within an organization. ISC perceptions include three facets: (a) structural or the value of information sharing, (b) relational or collegial trust, and (c) cognitive or the degree of shared goals and vision present among district educators (Leana & Pil, 2006; Figure 4.2). In this study, the ISC perceptions of the 20 elementary mathematics coaches and the elementary MISSL were measured using Leana & Pil's (2000) Internal Social Capital Scale (see Appendix N). Using the Qualtrics online survey platform (https://www.qualtrics.com/), all 21 participants completed the Internal Social Capital Scale twice, once at the beginning of the first professional development day in August 2017 and again at the end of the final session in February 2018.

Describing the data. After downloading and cleaning the data using Microsoft Excel, descriptive statistics were run to examine the distribution of scores in terms of patterns, trends, and frequencies. Overall, participants had moderately weak perceptions ($2.00 \leq M \leq 3.99$ on the

7-point scale) of all three ISC variables at the beginning of the study (structural: *M*=3.81, *SD* 0.65; relational: *M*=3.36, *SD* 1.31; cognitive: *M*=3.71, *SD* 1.12; see Table 5.4). Post-study data show perceptions of all three variables improved over the course of the study, with perceptions of both structural capital and cognitive capital, on average, becoming moderate ($4.00 \leq M \leq 4.99$ on the 7-point scale; structural: *M*=4.53, *SD* 0.65; cognitive: *M*=4.39, *SD* 0.94) and perceptions of relational capital improving, on average, to moderately strong ($5.00 \leq M \leq 6.99$ on the 7-point scale; *M*=5.17, *SD* 0.85; see Table 5.4). Perceptions of relational capital, showed the greatest improvement with average perceptions starting out lower and ending up higher than those for either structural or cognitive capital, indicating levels of collegial trust grew over the six-month time frame (pre: *M*=3.36, *SD* 1.31; post: *M*=5.17, *SD* 0.85; see Table 5.4). Disaggregated by team, data indicates perceptions of relational capital were the most positive of the three subscales for each team as well as the MISSL at the end of the study (see Figure 5.5).

Table 5.4

Descriptive Statistics: Internal Social Capital Perceptions (n=21)

Variable	Administration	*M* (*SD*)	Median	Min	Max
Structural Capital	Pre	3.81 (0.43)	3.83	2.50	5.50
	Post	4.53 (0.54)	4.33	3.50	6.40
Relational Capital	Pre	3.36 (1.71)	3.17	1.50	6.67
	Post	5.17 (0.72)	5.17	3.67	7.00
Cognitive Capital	Pre	3.71 (1.26)	3.67	1.17	6.00
	Post	4.39 (0.88)	4.17	2.00	6.33

Note. Responses based on a seven-point Likert scale ranging from strongly disagree (1) to strongly agree (7).

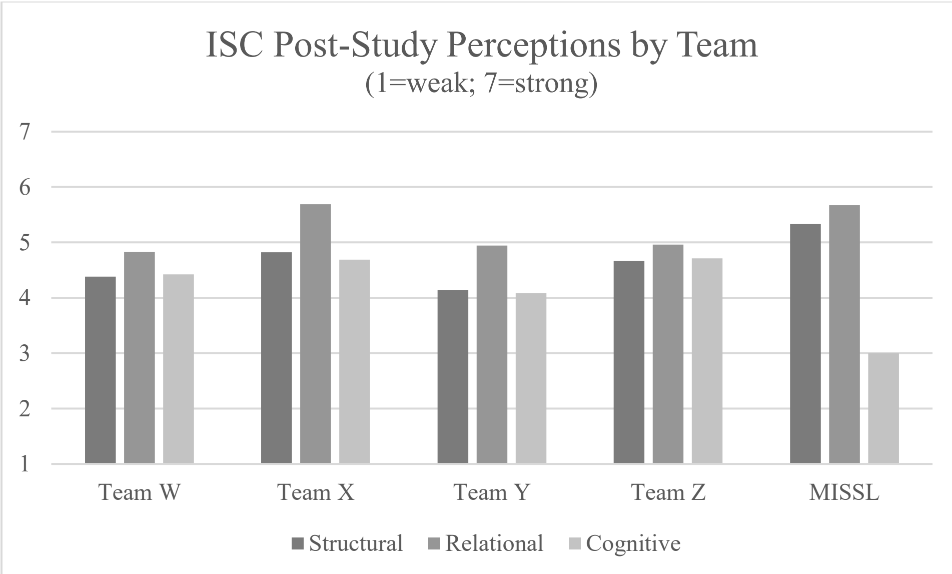


Figure 5.5. Post-test, internal social capital perceptions, disaggregated by team. See figure 4.2 for descriptions of subscales.

Determining significance. A paired-samples t-test for means was conducted to compare pre- and post-intervention perceptions of internal social capital (Table 5.5). A statistically significant change was found for participants' perceptions of all three components of internal social capital: structural capital [$t(20) = 2.92$, $p = .01$], relational capital [$t(20) = 6.09$, $p = .00$], and cognitive capital [$t(20) = 2.96$, $p = .01$]. This positive change in perceptions of internal social capital indicates participants' perceptions of the value of the actual and potential resources embedded in and created by the relationships between district educators for supporting mathematics teaching and learning became more positive over the course of the study.

Table 5.5

Paired Two Sample t-Test for Pre- and Post-Intervention Means: Internal Social Capital (ISC) Perceptions (n=21)

Variable	Administration	*M* (*SD*)	*t*	*p*
Structural Capital	Pre	3.81 (.43)	2.92	0.01
	Post	4.53 (.54)		
Relational Capital	Pre	3.36 (1.71)	6.09	0.00
	Post	5.17 (.72)		
Cognitive Capital	Pre	3.71 (1.26)	2.96	0.01
	Post	4.39 (.88)		

Note. Responses based on a seven-point Likert scale ranging from strongly disagree (1) to strongly agree (7).

Triangulating for deeper understanding of changed perceptions. Positive perceptions of collective efficacy for teaching enable educators to honestly analyze the impact their individual and collective efforts and actions have on student outcomes, based on the belief that they can promote student achievement regardless of systemic or structural factors (Goddard et al., 2000; Hattie, 2012; Moolenaar et al., 2012). Positive collective efficacy perceptions also allow individuals to see barriers as challenges to be collectively overcome, not impediments outside of their control. Analysis of feedback gathered from study participants at the beginning of the study identified three anticipated barriers related to conducting CIT work: (a) time for meeting and implementing the work on site, (b) buy-in from teachers in terms of engaging in the work, and (c) buy-in from principals in terms of prioritizing and aligning the work with other district and school-based initiatives. Meeting transcripts were coded for these three themes to determine how often the themes arose and team members' responses to topics related to these barriers. These coded instances were examined a second time and coded for emergent themes related to how team members responded to the mention of these barriers. Three main themes emerged, with team members either, (a) empathizing and adding their own similar experience with the identified barrier, (b) ignoring the topic, or (c) talking through the challenges of the barrier and collaboratively problem solving.

These three anticipated barriers came up more frequently within team Z's meetings than in those of the other teams. Team Z members brought up these three barriers 68 times within their discussions (time: n=20; teacher buy-in: n=25; principal buy-in: n=23). Members of team Z ignored the mention of the barrier, shifting to another topic 26% of the time, and worked to develop a solution for the problem 19% of the time. However, more than half of the time barriers were brought up (55%), team Z members appeared to empathize, adding their own similar experiences to the discussion, as can be seen in the following exchange from their November in-person meeting:

> *Z1: Yeah, and it's finding time to do that at CPT* [common planning time]
>
> *Z2: Yeah, and who's there and who's not there and who doesn't have coverage and all that. You know and we've had half of CPT time taken over by other things like interims. It's been really frustrating.*
>
> *Z3: Yeah, and we've had a bilingual classroom where the kids have been split since probably the beginning of October.*
>
> *Z2: Oh, boy*
>
> *Z3: So, I think that's part of what administration has been dealing with. And we've had all these classes that have been split and then classes that have been split upon splits. Like we had a teacher get stung by a bee one day, so we had to*

split her classroom and there were already three classes that had been split. It's been crazy.

Z2: Right, but that's the reality. And I tell people when they walk into classrooms don't be surprised to see like 30 plus kids in a classroom and some kids just sitting in the back of the room just working on some worksheets.

Z3: Yeah.

Z2: Yeah.

In this conversation, Z1 raises the time barrier, citing a lack of time to work on the team's inquiry work and Z3 and Z2 empathize (e.g., *Oh, boy*) and add their own experience sharing evidence of the problem within their contexts as well (e.g., *Yeah, and we've had a…*). At no point in the conversation do team members engage in analysis of the problem or propose potential solutions, instead they just acknowledge the existence of this barrier – a lack of time (e.g., *Right, but that's the reality*). Discussions, such as this, where team members identify external barriers to effective mathematics teaching learning without engaging in critical analysis of or reflection on potential solutions indicate both negative C-MEFT perceptions and a lack of critical colleagueship development (Goddard et al., 2000; van Es, 2012)

All three barriers came up at meetings for the other three groups as well, but not as often. For all four teams, teacher buy-in was the most discussed barrier (*n*=53), followed by time (*n*=33), and then principal buy-in (*n*=32). Teams Y and X responded to discussion of barriers by engaging in collaborative problem solving most of the time (Y = 78%; X = 79%). For both teams, not only were barriers raised as part of the general conversation, but individuals explicitly brought specific struggles across these three areas to the team asking for help. For instance, at team Y's October virtual meeting a team member brought up a struggle she was having with both finding time for CIT work and getting buy-in from her teachers:

> *Y2: I wonder…I'm having trouble dealing with what my day-to-day reality is at this time. I'm feeling like if there is something that we are doing for someone else how we can incorporate this into our daily work. I'm feeling like I'm having trouble getting traction into this work. Maybe it's because I'm new this year and I missed all of the work last year.*
>
> *Y3: So, I have a question. Do any of the small wins help bring this* [our CIT work] *to your day-to-day?*
>
> *Y2: I think so.*
>
> *Y3: So, maybe that is the way to go. Y2, do you think any of the small wins would help to bring it to your day-to-day?*
>
> *Y2: I think maybe. I feel good about it when I'm filling out this form, but then when I'm back at my school I'm having trouble seeing how this fits in to what I'm trying to do.*
>
> *Y4: I'm wondering if you should try to find one teacher that you can start this work with and then build from there.*
>
> *Y2: Yes. Absolutely.*

In this exchange, Y2 appears to have trusted her team members to support her struggle and not judge her struggle to implement the team's action plan at her school as a weakness. Instead of empathizing with her, Y3 and Y4 provided suggestions for small steps Y2 could take to move forward with their CIT work within her own context (e.g., *I'm wondering if you should try…*). Professional exchanges where team members share struggles and offer suggestions for overcoming potential barriers promote C-MEFT perceptions by demonstrating collective capacity. This type of open exchange of problems and potential solutions also supports critical colleagueship development through collective reflection on mathematics teaching and learning practices connected to specific practice-based incidents (Hamann et al., 2001; Males et al., 2010; van Es, 2012).

Examining the Process

Although the outcome evaluation shows a statistically significant positive change to participants' perceptions of both collective mathematics efficacy for teaching (C-MEFT) and internal social capital (ISC) this does not conclusively determine intervention effectiveness. A process evaluation will support a systematic analysis of whether the intervention was implemented as intended, whether critical colleagueship developed for each team, and allow for further interpretation and explanation of outcome evaluation results to determine whether improved perceptions of C-MEFT and ISC can be attributed to the intervention itself (Dusenbury, Brannigan, Falco, & Hansen, 2003; Saunders, Evans, & Joshi, 2005). The summative process evaluation of this study analyzed: (a) participants' level of engagement in the structured collaborative inquiry process, (b) the influence of the blended learning structures and systems on collaborative inquiry team (CIT) work, and (c) the influence of different levels of individual participant engagement on critical colleagueship development.

Analysis of critical colleagueship development. A mediating variable in this study, critical colleagueship refers to the degree to which a group of educators engage in discussions that support group knowledge development and critical analysis of or reflection on existing practices and beliefs about mathematics teaching and learning (Kintz et al., 2015; van Es, 2012). There are three key aspects of critical colleagueship development: collaborative interactions (the degree of involvement of multiple individuals), participation and discourse norms (the degree of elaboration upon and/or probing of multiple perspectives) and focus of activity and discussion (the degree of reference to specific versus general experiences or ideas; van Es, 2012). The audio recording of each CIT meeting[1], the unit of analysis, was transcribed by the researcher and then analyzed for each of the three aspects of critical colleagueship development using a revised version of van Es' (2012) three-stage rubric (beginning, intermediate, and high-functioning) for community development, to examine development from conversations with limited exploration of single perspectives to conversations characterized by active probing and elaboration of multiple, practice-based perspectives (see full rubric in Appendix L).

Seeking to better understand the nature and content of CIT discussions in terms of both participation and discourse norms and focus of activity and discussion, additional analysis of meeting recordings was done using a priori codes developed by Ke and Xie (2009) for analysis of online learning interactions (see Table 5.6). Individual statements within each meeting transcript were coded as representing knowledge construction or regulation of either team or individual learning. Knowledge construction consisted of four stages, progressing from simple, individualistic sharing of information and ideas (K1), to egocentric elaboration on ideas (K2), to comparing and synthesizing multiple perspectives (K3), and finally to planning future, school-based application of new ideas (K4). Regulation of learning consisted of three components: teamwork planning and coordination (R1), self-evaluation and regulation (R2), and technical issue management (R3).

[1] Not all CIT meetings were analyzed for critical colleagueship development. The two August meetings were planning meetings with teams creating a team charter and a goal for their inquiry work. Because team members were getting to know each other, and the discussion was primarily procedural, they were not recorded or analyzed. Likewise, the January in-person meeting involved teams reviewing their inquiry work and preparing presentations for the February meeting, so they were not analyzed. The February meeting consisted of teams sharing their goals, progress, and next steps, so it did not involve team-based discussion.

Additional data about collaborative interactions were collected by tabulating the number of times each individual spoke at each meeting to determine the percentage of contributions for each individual. And additional data about discussion and participation norms were collected by highlighting when new topics were introduced and whether new topics built on or were disconnected from the current topic, as well as highlighting when individuals interrupted others.

Table 5.6

Coding for Analysis of Collaborative Inquiry Interactions.

Code	Category		Definition and Examples
K1	Knowledge construction	Information sharing	Simply adding fact or opinions without elaboration.
K2		Egocentric elaboration	Elaborating on own or other's statements by citing one's own related experience or observation
K3		Allocentric elaboration	Comparing and/or synthesizing ideas, by summarizing, making judgments, and extending ideas
K4		Application	Planning and discussing future application of ideas in schools/classrooms
R1	Regulation of learning	Coordination	Teamwork planning and coordination
R2		Reflection	Self-evaluation and self-regulation
R3		Technical issues	Questioning and answering technical issues

Note. Adapted from Ke and Xie's (2009) online learning interaction model (p. 140).

Inter-rater reliability. Data reliability refers not to the reliability of the scale itself, but instead the consistency of scores obtained from that scale (Barry, Chaney, Piazza-Gardner, &

Chavarria, 2014). The three-stage rubric used to determine critical colleagueship development requires an evaluator to make subjective judgements about the degree to which identified elements are present in a conversation in terms of the clearly defined criteria. To promote internal reliability, inter-rater reliability, or the degree of consensus two or more independent raters have based on a pre-established rubric or scoring protocol (Barry et al., 2014; Stemler, 2011), was determined for the first round of in-person meetings. These four meeting transcripts, one for each CIT, were analyzed independently by the researcher and by a second individual (an associate professor of mathematics education with a background in analyzing group discussions) and then the scoring was compared. The most common inter-rater reliability consensus estimate is the percent agreement statistic, with values of 70% or greater being considered acceptable in the social sciences (Stemler, 2011). There was 83% inter-rater reliability across the four meeting transcripts, with agreement on 10 of the 12 component scores on the rubrics. The two discrepant scores were both in the focus of activity and discussion component, with the researcher's score for team Y's and team W's discussion one-half point higher than the second rater (n=1.5 versus n=1 on a 3-point scale). Because there was an acceptable level of agreement, the researchers' scores were used for all subsequent meeting transcripts.

Development over time. Based on social cognitive and social capital epistemologies (Bandura, 1986; Minckler, 2014), it was hypothesized that increased engagement in structured collaborative inquiry would promote critical colleagueship development, as team members built trusting relationships and engaged in self-reflective learning and professional discourse around a shared problem (Lord, 1994; Kintz, et al., 2015; van Es, 2012). As the graphs in Figure 5.6 show, critical colleagueship did not develop in a linear manner for any of the teams, however with the exception of team Z, there was an upward trend, with all three components ending at a higher level of development for teams W, X, and Y. This development of critical colleagueship indicates team W, X, and Y discussions progressed from focusing on individual interests and general ideas to including active analysis of diverse perspectives and the development of shared understanding (Males et al., 2010; van Es, 2012).

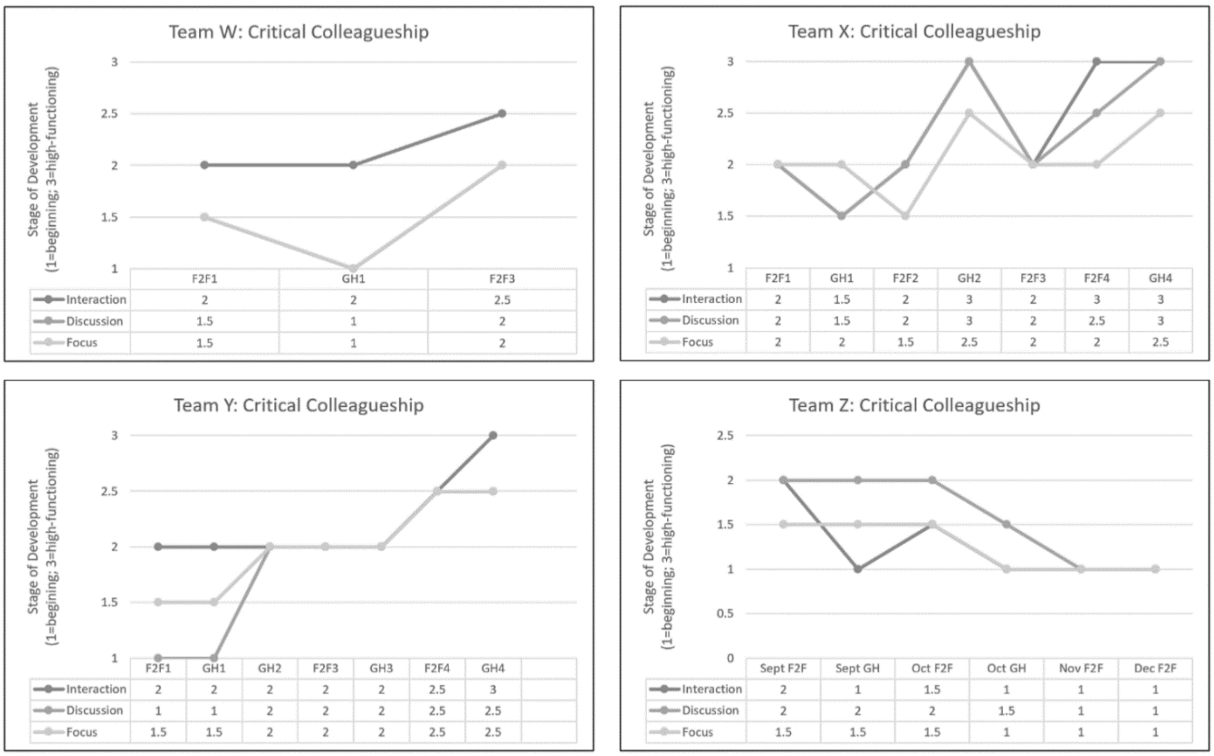


Figure 5.6. Critical colleagueship development by team, across meetings. F2F connotates an in-person meeting. GH connotates a virtual, Google hangout meeting. Scores are only listed for meetings that were recorded (see footnote 1).

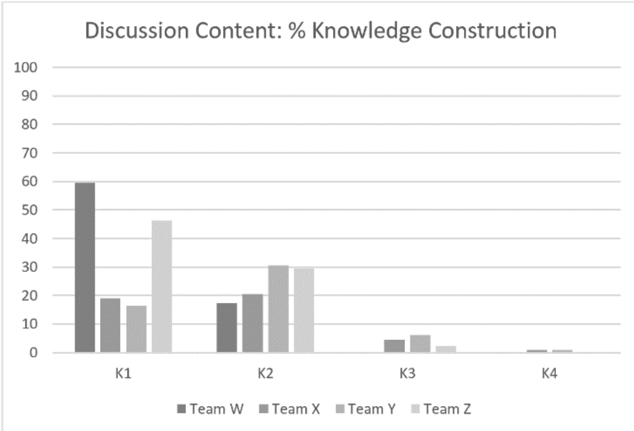
Team Z. The discussion at team Z's initial in-person meeting was the strongest in terms of critical colleagueship, with both collaborative interactions and participation and discourse norms being at an intermediate stage on the three-stage rubric (van Es, 2012), and with all members contributing to the conversation and building upon each other's ideas (Figure 5.6). The focus of their initial discussion was between a beginning and an intermediate stage in that it was focused on the team's goal but was not grounded in shared referents or specific mathematics teaching and learning events in district schools. Subsequent meetings, both in-person and virtual, lacked both a focus on the team's goal of using data-based planning to increase student engagement and equitable involvement by all team members. One team member (Z4) rarely spoke during meetings (accounting for only 8.3% of the discussion contributions across all meetings). The other three members contributed relatively equally to discussions (Z1=22.6%, Z3=32.2%, Z2=37.3%), but primarily talked about technologies being used at their respective schools and the impact of other district initiatives on their ability to engage in instructional coaching work. Overall, almost half of their discussion time, across all meetings, was at the K1 level (*M*=46.2%; Figure 5.7), as individuals shared what was happening at individual schools with minimal probing or connecting of ideas. Overall, team Z completed the study at the beginning stage for all three aspects of critical colleagueship development (Figure 5.6).

Team W. As is evident in the critical colleagueship development graphs (Figure 5.6), team W did not meet regularly, holding only one virtual meeting and two recorded in-person meetings[2]. Development of collaborative interactions was the only component that progressed from a beginning to an intermediate stage, with all members being actively involved throughout the discussion (van Es, 2012). The majority of contributions to the discussion (*M*=59.8%) consisted of information sharing (K1), with coaches discussing work being done at individual schools. Despite not meeting very often, critical colleagueship did develop across all three areas to the intermediate stage, the reason for which is not clear. Critical colleagueship development was evident during their November in-person meeting where 30.3% of the conversation involved

[2] Team W's October in-person meeting was not recorded due to scheduling and technical issues. Their December meeting was not recorded because there was only one person in attendance. Although they scheduled a virtual meeting for each month, they cancelled all of these meetings at the last minute, except for the first one in September.

individuals connecting their own experiences to those of others (K2), up from 23.6% at the first in-person meeting and only 6.2% at their virtual meeting (Figure 5.7).

Teams Y and X. Both team Y and team X showed critical colleagueship development across all three components. Team Y progressed from a beginning to an intermediate stage in both participation and discourse norms and focus of activity and discussion and from an intermediate to a high-functioning stage in collaborative interactions (van Es, 2012). Team X progressed from an intermediate to a high-functioning stage of development across all three areas (Figure 5.6). Unlike teams W and Z, whose conversations primarily involved individuals sharing ideas and information (K1), teamwork coordination (R1) accounted for the largest portion of team Y's (*M*=37.5%) and team X's (*M*=46.7%) discussions (Figure 5.7). Team Y's and X's teamwork coordination included establishing meeting agendas, coordinating meetings and school visits, clarifying team goals, and ensuring all team members agreed with next steps and expected deliverables. In contrast teamwork coordination only accounted for 13.0% of team Z's discussion and 18.8% of team W's (Figure 5.7). Additionally, when discussion centered on developing knowledge, individuals from across both team Y and X had at least as many, if not more interactions building upon and connecting to each other's ideas. Team Y had approximately twice as many level K2 interactions (*M*=30.6%) as K1 interactions (*M*=16.5%). Team X had equal amounts of both types of knowledge-based interactions (level K1 and K2; *M*=20.6%). Both teams also had multiple interactions Ke and Xie (2009) would label as allocentric elaboration (K3), with individuals synthesizing, probing, and challenging the ideas of others (Figure 5.7).



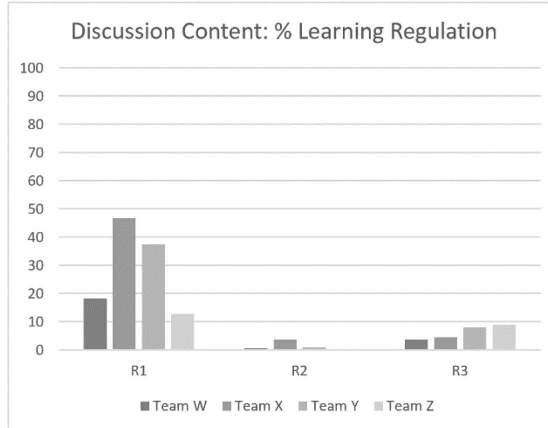


Figure 5.7. Analysis of discussion content for both levels of knowledge construction and types of learning regulation by team across meetings using Ke and Xie's (2009) online learning interaction model. See Table 5.6 for descriptions of the specific codes. Percentages are based on the number of statements within each meeting discussion.

Influence of blended learning structures and systems on critical colleagueship and collaborative inquiry teamwork. Throughout the intervention individuals and teams had access to G-Suite for Education tools and Google classroom space within the district's website. Individuals from all four teams took advantage of these tools to support their CIT work, including email, Google docs and sheets, Google drive, and the communication stream within the Google classroom each team created during their first meeting. Teams also all used Google hangout to hold monthly virtual meetings and met in-person once each month. The researcher also shared just-in-time resources with CITs through Google drive and their Google classroom communication stream as needs arose.

Using an online survey through Qualtrics (https://www.qualtrics.com), participants provided feedback each month regarding how often they used G-Suite for Education tools and how valuable they felt the different tools were for supporting their CIT work. Frequency tabulations were conducted for each tool by month to determine actual usage by team. Microsoft

Excel was then used to calculate summary statistics for these three data sets to examine patterns and trends of tool use, including measures of central tendency and variance. This quantitative analysis was then triangulated with critical colleagueship development by month to determine plausible connections.

Team Z. Team Z reported using Google drive and Google docs approximately weekly throughout the study, except during the month of December. They reported using email and the Google classroom communication stream only once or twice each month. Interestingly, their perceived value of the G-Suite tools was highest during the month of December, when no actual usage was apparent within their shared space and when they reported using each of the tools only once or twice on their monthly feedback survey.

As described earlier, Team Z was the one team that did not develop critical colleagueship according to analysis of meeting transcripts using van Es's (2012) three-stage rubric for the development of teacher learning communities. Interactions within their September and October in-person meeting transcripts represented their highest levels containing elements of discussion between beginning and intermediate stages for all three critical colleagueship variables. Frequency tabulations show that team members actually used the G-Suite tools the most during the month of October, interacting five times within their Google classroom communication stream, adding four resources to their Google drive, sending each other two group emails, and collaborating on two Google docs. When viewed together, trends in actual tool use, and participants' perceptions of both CIT productivity and adherence to charter agreements all appear to follow their critical colleagueship development trends, being higher during the first few months of the study and declining over the final three months (see Figure 5.8). Although team Z did not report finding the G-Suite tools valuable in terms of their CIT work in October, it does appear that greater actual use was associated with higher levels of critical colleagueship at their early team meetings. This association between actual G-Suite tool use and higher levels of critical colleagueship may be because, as one member commented, the G-Suite tools *allow us to communicate in many different ways and to work more efficiently* (Z3, October feedback survey).

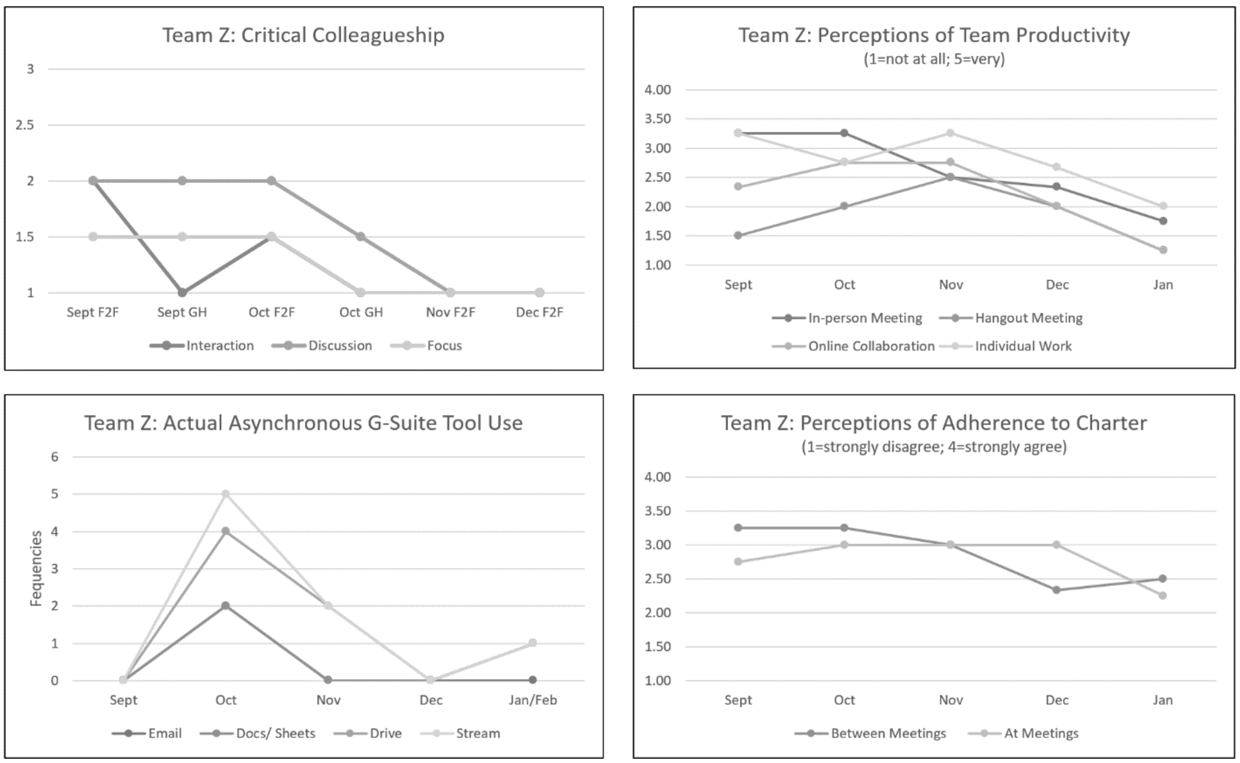


Figure 5.8. Connections between blended learning environment elements and critical colleagueship development over time for Team Z.

Team Y. Members of team Y reported feeling their asynchronous individual and online collaboration was most productive in November, as one member stated: *We are starting to rely on each other more. Through texts and our hangout, we are starting to feel like a team* (Y4, November feedback survey). November was also the time when team Y reported using the G-Suite tools the most and when they felt the tools were most helpful in supporting their CIT work, as indicated by the comment: *I find being able to post items in the Cohort Y classroom to be easy to access and very useful* (Y1, November feedback survey). Additionally, team members all felt everyone had adhered to their charter agreements both during and between meetings and that the team had achieved most of its goals for the month. At their November in-person meeting the team's discussion reflected elements of the intermediate stage of van Es' (2012) team development framework. Their critical colleagueship continued to develop toward a high-functioning stage during subsequent meetings. Although these critical colleagueship development trends do not align with actual tool use for team Y, it does appear to be connected to team members' perceptions of the use and value of the blended learning design elements.

Team X. Members of team X consistently reported using all of the G-Suite tools once or twice to weekly throughout the study. Their greatest actual usage was during September when 15 items were added to their shared Google drive and there were 45 interactions or postings within their Google classroom communication stream, many related to organizing and accessing meetings and materials within their online platform. Team X reported feeling they were productive in all aspects of their CIT work throughout the study and that all team members adhered to charter agreements both at and between meetings, consistently completing monthly goals. Critical colleagueship development for team X progressed from an intermediate stage toward a high-functioning stage in all three areas, but patterns of critical colleagueship development do not appear to align with either actual or perceived tool use or team productivity. Multiple team members added comments to their monthly feedback survey indicating their positive collaboration, including:

- *It is great to work on a team with different members who move forward to the lead or step back based on the needs of the group (X1, September),*
- *Seriously - I hope we can continue to collaborate and be as great as we have been as a team (X2, October), and*

- *It has been a rewarding professional experience so far (X3, November).*

The team's consistently positive feedback and perceptions of capacity and interdependence are consistent with overall critical colleagueship development to a high-functioning stage of team development.

Team W. As was discussed earlier, team W did not meet regularly, cancelling all but their first virtual meeting and having to cancel one in-person meeting because only one team member was in attendance. Team members also reported, and actually used, the G-Suite tools only occasionally. Despite this lack of engagement in the collaborative inquiry process, conversational analysis shows that critical colleagueship did still develop in team W with elements of their final scored (see footnote 1) in-person meeting in December representing an intermediate stage of team development for all three aspects of critical colleagueship. Team members valued the opportunity to collaborate, commenting: *We are like-minded and enjoy sharing ideas and resources with each other (W3, October feedback survey),* but also recognized their collaboration had been limited, stating on the January feedback survey, *I hope that our work today will serve as a "restart" and that we will continue moving forward. We have some actionable steps to prepare for our next hangout and coaches' meeting* (W2). Overall, team W had productive conversations when they met in-person but did not participate in the overall collaborative inquiry process with fidelity.

Implementation fidelity and critical colleagueship development. Implementation fidelity in terms of dosage in this study was determined through frequency tabulations of engagement in in-person, virtual, and asynchronous online collaborative inquiry. High fidelity was defined as a team having 100% of its members actively engaged in all meetings as well as asynchronously. No team met this level of fidelity, but teams X and Z both had relatively high fidelity. Team Z cancelled one Google hangout meeting due to scheduling conflicts and had one member absent for one other meeting. However, only three team members collaborated asynchronously and actively contributed to meeting discussions. The third team member shared only one resource online and only accounted for 8.3% of discussion contributions. Team X held all of its meetings and never had more than one of their six members absent from a meeting, with three team members each missing one meeting. All team members collaborated asynchronously communicating and sharing resources online and actively participated in team discussions. Team W had low fidelity cancelling two virtual meetings and one in-person meeting. Additionally, only one team member was present at all team meetings, with two of the other members each missing one meeting, and the fourth member missing four meetings. When team members were in attendance, they all actively contributed to discussions. However, only one team member actively shared resources and communicated online. Team Y had moderate fidelity. The team held all of its meetings and all but one if its members actively participated in team discussions and collaborated asynchronously through Google classroom. Three of its team members were present at all meetings, while two members each missed one meeting, and one member missed three meetings.

Team charters. Two key structural components of the intervention were the development of team charters and collaborative inquiry action plans. All four teams successfully developed a team charter to provide guidelines for communication and collaboration. On monthly feedback surveys, individuals indicated their level of agreement with the statement: "This month my team members and I adhered to our team charter, in terms of expectations for communication and collaboration" both at monthly in-person and virtual meetings and online, between meetings. Responses were given on a four-point scale ranging from strongly disagree (1) to strongly agree

(4). Team X members reported strong agreement that they adhered to their charter throughout the study, both at (*M*=3.59, *SD*=0.36) and between meetings (*M*=3.39, *SD*=0.37). Members of the other three teams reported either somewhat agreeing or agreeing that team members adhered to their charter throughout the study, fluctuating somewhat month-to-month (see Figure 5.9).

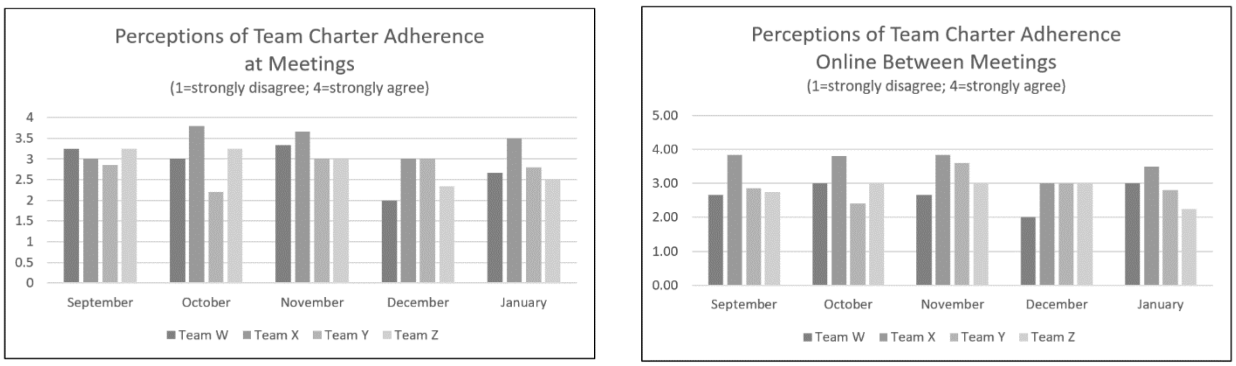


Figure 5.9. Average perceptions of team charter adherence by month, both online between meetings and at meetings. Responses indicate degree of agreement (1=strongly disagree; 4=strongly agree) that team members adhered established charter agreements regarding collaboration and communication.

When discussing charter adherence at their November in-person meeting, members of team W had the following exchange:

> *W1: Right, so when we are together I think we do a great job of collaborating, we just didn't have time the other day to do our hangout*
>
> *W2: Right, when we're together we get lots done, but it's just hard with all of the other responsibilities that we have. Like the other day, my principal needed me to do something else when we were supposed to be meeting, so that makes it really hard and then we have to try to align our schedules again to make up that time.*

W3: Yeah, we have so many people asking things of us, that it's hard to get together.

W2: But as far as adhering to our charter, I personally don't feel like any of us is letting the other people down

This exchange indicates that even though they did not always meet the responsibilities laid out in their charters and action plans, team members felt they were not letting each other down.

CIT action plans. To guide their work, each team created an action plan to promote achievement of their collaborative inquiry SMART goal. An implementation fidelity indicator was the achievement of the three action steps or "small wins" teams established in their CIT Action Plan to promote goal achievement. At the final meeting in February, each team reported out their progress to date, including whether their "small wins" had been achieved. Team Z reported having established a single shared goal (increasing opportunities for student engagement during the math block) but having chosen to have each individual determine their own "small wins" at their respective schools. Although team Z members reported having achieved most of their school-based "small wins" it is questionable whether this indicates implementation fidelity because members were not working interdependently, a key criterion for working as a team. Team Y and team X reported achievement of all three of their "small wins" and described next steps to continue progress toward their larger goal of increasing student engagement and student-to-student discourse over the remaining half of the school year. Team W reported that they had not completed any of their three "small wins," with all still being in progress, including determining a strategy for collecting baseline data and developing a bank of high quality mathematics tasks to promote authentic student-to-student conversations during mathematics instruction. The team did share that they had spent a lot of meeting time calibrating their definition and vision of student-to-student discourse, work they felt would enable them to determine what data they would need to collect to identify specific areas of need and how to best support high quality mathematics discussions in classrooms at their individual schools.

Conclusions

This study sought to determine the effect of regular, structured collaborative inquiry on a group of elementary mathematics coaches' perceptions of both collective mathematics efficacy for teaching (C-MEFT) and internal social capital (ISC). Additionally, the study examined the influence of implementation factors and facets on the development of critical colleagueship at the team level, with the belief that its development would strengthen C-MEFT and ISC perceptions.

Changes to C-MEFT and ISC Perceptions

Results of a paired-samples t-test for means indicate a significant, positive change to both C-MEFT variables across all teams: group competency ($p = .04$) and task analysis ($p = .04$) and all three ISC variables: structural capital ($p = .01$), relational capital ($p = .00$), and cognitive capital ($p = .01$) for these elementary mathematics coaches, as a whole. This significant change indicates participants developed more positive perceptions of the collective ability of educators throughout the district to effectively teach mathematics and promote students' mathematics achievement. These findings also indicate more positive perceptions of the value of the human and structural capital within the district and the power of their professional relationships to support and distribute that capital within and across schools.

Attribution to Intervention

Whether these positive changes to perceptions of collective capacity can be attributed to the intervention or the development of critical colleagueship is not certain. Wholey, Hatry, and

Newcomer (2010) explain that in social science causality often cannot be determined, but instead researchers must work to determine plausible attribution of the intervention on intended behaviors. This attribution involves considering the timing of outcomes, the extent of the outcomes, and confounding factors. The pre-post-test design of this study's quantitative analysis satisfies the timing element as perceptions were examined on the first and the last day of the study. The paired samples t-test satisfies the element of the extent of the outcomes as the positive change to perceptions was significant for all dependent variables. The study's process evaluation sought to eliminate confounding factors by examining implementation fidelity in terms of (a) dose delivered (the extent to which components were put into place and delivered to participants) and (b) dose received (whether intended participants were adequately reached by program components; Dusenbury et al., 2003; Saunders et al., 2005).

Dose delivered and inquiry process fidelity. Analysis of implementation fidelity involved examining the extent of involvement of participants, by team, in all three intervention components (in-person meetings, virtual meetings, and asynchronous on-line collaboration) as well as the development of and adherence to team charters and collaborative inquiry action plans. Two of the four teams (X and Y) held all scheduled meetings (7 in-person and 5 virtual), team Z cancelled one virtual meeting, and team W cancelled four of its five virtual meeting and one of its in-person meetings. Additionally, all teams had at least one team member miss a meeting and two teams had a member who missed three meetings. Reasons for absences included illness and personal days, as well as principals requesting coaches remain at school sites to teach in classrooms for which there was no available substitute. All teams established a Google classroom space and communicated and collaborated using available G-Suite for education tools throughout the study.

As discussed earlier, scheduling issues cut the total planned meeting time by one-third from the original design, meaning that some intervention elements had to be eliminated, including team building time and cross team sharing and support. Also, as discussed previously, the district's elementary mathematics instruction school support liaison (MISSL) was unable to facilitate CIT meetings as planned, leaving members to meet independently, with as needed guidance from the researcher.

All four teams successfully developed a team charter and a CIT action plan, that included a year-long SMART goal aligned to their school improvement plans and three "small win" action steps to support overall goal attainment. Teams referred to and revised these plans throughout the study as progress was made and needs arose. When sharing out their work and revised goals at the final meeting in February, all teams reported having made progress on or having fully accomplished their "small win" action steps. Team W reported that *due to unforeseen circumstances* (member illness and principal requests) it had not completed any of its "small wins," but that progress had been made on two goals: developing a bank of high quality tasks for teacher use and creating and using classroom instruction videos to promote discussions among grade level teaching teams. Team W members stated that *building rapport and collaboration between our cohort members was the most beneficial aspect of our cohort work* (as written on their presentation slide). Team Y also reported having made some progress on its "small wins": guiding teachers in choosing high quality tasks to promote student discourse, providing modeling and support for teacher use of strategies that support student reasoning and discussion, and encouraging teachers to create a student-centered environment. Team X reported having accomplished all three of its "small wins": developing a "look-for" tool to observe levels of student-to-student discourse in classrooms, revising the "look-for" tool after piloting it in classrooms, and then using the revised tool to collect data and evaluating its value for engaging teachers in discussions around improving classroom practice. Team Z was unique in that although they had a shared long-term goal (supporting development of increased opportunities for active student engagement during mathematics instruction), each coach had unique “small win” goals they were enacting at each school. The team explained that due to principal demands and school-based priorities, they had not come to consensus around shared action steps. Similar to team W, team Z reported valuing the opportunity to regularly meet and *bounce ideas off of each other* (Z2, February presentation) as they worked to promote more student-centered mathematics instruction at their schools.

As a result of these implementation factors, high fidelity was not reached for any team with dosage issues resulting from both contextual factors and levels of personal engagement. This lack of fidelity limits the researcher’s ability to attribute outcomes to the intervention design as degree of fidelity does not appear to align with critical colleagueship development, the intervention output theorized to influence changed C-MEFT and ISC perceptions, as described next.

Reach and dose received. Regularly engaging in purposeful conversations around daily practice helps build the cohesion, collegial trust, and supportive relationships needed to support the public self-reflection and professional discourse that promote critical colleagueship development (Kintz, Lane, Gotwals, & Cisterna, 2015; Lord, 1994; van Es, 2012), this intervention’s output. Critical colleagueship development progresses from beginning to high-functioning stages across three variables: collaborative interactions, participation and discourse norms, and focus of activity and discussion (van Es, 2012). Critical colleagueship development was evident in the meeting transcripts of three of the four CITs in this study (W, X, and Y).

Teams X and Y reached a high-functioning stage of development for at least one component based on van Es' (2012) three-stage rubric. The discussions of these two teams were different from those of the other two teams in two ways. First, team members regularly connected to and probed each other's ideas and brought issues to team members explicitly asking for support and advice. Second, both teams actively worked to coordinate their collaborative work, with 37.5% of team Y's interactions and 46.7% of team X's interactions being devoted to establishing agendas, coordinating shared work, and ensuring all team members were clear about next steps and deliverables.

Team Z was the one team that did not develop critical colleagueship with conversations representing an intermediate stage of development during the first two months and only a beginning stage over the final three months, based on van Es' (2012) three-stage rubric. Team Z's discussions primarily consisted of members sharing and comparing school-based work and experiences, without the collaborative discourse indicative of critical colleagueship. Team members spoke positively of the CIT work and collaboration opportunities, with one member commenting at their November in-person meeting:

> *You know, it's kind of nice at these meetings to just be able to talk and catch up with you guys about what is going on at our different buildings, because it's been so structured that we hadn't really been able to debrief and talk about what's going on (Z1).*

Based on Wenger, Tayner, & deLaat's (2011) framework for assessing value creation in professional learning communities, Booth and Kellogg (2015) propose participants find value in online communities in different ways, moving through a developmental cycle that begins with enjoyment of engagement with peers by discussing and sharing ideas. The statement above (*it's* *kind of nice…to just be able to talk and catch up…*) as well as their final presentation statement, *bouncing ideas off of each other was a great benefit,* may indicate team Z is at this beginning stage of value creation. Over time, this initial stage, where members simply enjoy engaging with peers, provides opportunities for trust development and vicarious success experiences as members listen to peers' ideas, an identified source of positive efficacy development (Bandura, 1986). So, although team Z's discussions did not reflect the discourse and interdependence characteristic of high-functioning critical colleagueship, the idea exchange and trust development occurring during these meetings may still account for improved C-MEFT and ISC perceptions, as well as members satisfaction with the process.

Discussion

Tenets of social cognitive and social capital theories suggest positive perceptions of collective efficacy for teaching and strong professional support networks promote organizational capacity in terms of both ongoing professional growth for educators and student achievement (Bandura, 1986; Coburn et al., 2012; Daly et al., 2009; Minckler, 2014). Needs assessment data from the beginning of this study, revealed that Libertyville's elementary mathematics coaches lacked confidence in the collective capacity of district educators to promote students' mathematics achievement. Anecdotal evidence suggested a lack of collegial trust and minimal inter-school professional exchanges were negatively impacting coaches' C-MEFT perceptions. To combat these mediating factors, this intervention was designed to strengthen and expand coaches' professional support networks by supporting regular engagement in collaborative inquiry to promote interdependence among these school-based instructional leaders.

The key mediating variable of interest in this study was the development of critical colleagueship within the four collaborative inquiry teams (CITs), as it is engagement in public reflection and collaborative discourse around practice that promotes self-reflection and continued efforts toward improvement (Hamann, Lane, & Johnson, 2001; van Es, 2012). Critical collegiality, especially when connected to daily practice, also creates cognitive disequilibrium and promotes meaningful change as educators consider multiple perspectives, examine new ideas, and debate their usefulness within personal contexts (Loucks-Horsley & Matsumoto,1999; Puchner & Taylor, 2006; Strahan, 2003; van Es, 2012). As the following exchange from team Y's December in-person meeting illustrates, when critical colleagueship is present individuals willingly expose struggles and openly listen to alternative perspectives that may lead to improved teaching and learning:

> *Y3: …that was the classroom I was talking about that doesn't do any whole group instruction. They only do small group because they have so many severe kids. You know, what would be the point of doing that whole class when they wouldn't be getting anything out of it. I'm not trying to be mean, but we have some really unique kids at our school that just need something else. I'm not even sure that having them in this classroom is the best place for them. I know some special educators would disagree with me, you know least restrictive and all. But anyway…*
>
> *Y2: But I think you're asking the right question. What is the purpose? Just getting into what are their needs and how are you meeting them.*
>
> *Y3: Those kids are just so isolated in that classroom already, and if I went in there and was like we're going to do a number talk with everyone. I would just be setting things up for failure.*

Y4: So, why don't you just go in and set it up for the kids that it would be appropriate for, so the teachers can see how it works.

Y2: Right and then they could think about how to adjust it to work for the other students.

Y3: Oh yeah. That might work. I mean there are only a few students who are really severe and then a few who are just really, really low.

Y4: Right, so you can go in and think about what would be your purpose and goal for the number talk.

The solution focused nature of this conversation contrasts with one from team W's November in-person meeting where an issue was raised and acknowledged, but not grappled with by team members:

W4: So, you know it's the same old discussion. Some of us coaches are placed in rooms with undesirable teachers.

W3: Right, I have these teachers who have these big binders and they're like this is what I taught last year at this time and so this is what I'm going to teach at this time this year.

W4: That's so maddening.

W3: Right. And I have so many teachers with no flexibility. And they're supposed to be working in a team because we have the dual language program where students have one teacher for math half the week teaching in English and the other teacher for the other half of the week teaching in Spanish. And the two teachers will not collaborate. You know. They say, I don't want to teach it that way. That's not how I do it. And so the kids are getting no consistency… So, I *guess my question to you, is how did you break through with your teachers. How did you get through when you have this administrator who is just like this is how things need to be done and I don't necessarily agree with that. I don't know. I don't know. I can't even get them to be talking about standards instead of strategies. There's just no common ground.*

W4: I don't know how to best make that happen in your situation because to be successful those teachers really have to collaborate and if they're not willing to compromise at all, I don't know how you make that happen.

Ernest and colleagues (2013) propose that collaborative learning goes beyond exchanging information, involving reciprocity and comparing points of view to produce higher quality knowledge construction than could be developed individually. Critical colleagueship development, or the progression from discussions focused on individual interests and references to active dialogue with participants probing and elaborating on each other's ideas to promote shared understanding of diverse perspectives (van Es, 2012), promotes deep learning, social network development, and beliefs in collective capacity.

Recommendations

Based on an examination of this study's results and existing empirical literature, it appears three key factors most influence critical colleagueship development within collaborative inquiry teams and promote positive C-MEFT and ISC perceptions: (a) balancing structure and autonomy for CIT work, (b) structuring conversations around shared versus personal referents, and (c) attending to team development in terms of culture and expectations.

Balancing structure and autonomy. With a goal of promoting both sustainable professional learning support and the instructional leadership capacity of the elementary mathematics coaches who participated in this study, autonomy and agency were key considerations of the CIT design. Teacher agency supports feelings of community belonging, helps educators connect learning to daily practice, and promotes social capital as individuals draw upon each other's expertise and experience (Calvert, 2016).

As discussed earlier, CITs were tasked with developing goals and action plans based on school improvement data and aligned to district initiatives, as well as developing a team charter for collaborative norms that provided guidelines for their bi-monthly meetings and asynchronous, school-based work. However, knowing that adults are not all self-directed learners willing to take initiative and persist in the learning process, the initial intervention design also provided for meeting facilitation by one of the district's elementary mathematics instruction school support liaisons (MISSLs). Personnel changes at the beginning of the school year precluded the MISSL from facilitating team meetings, a factor that may have limited the productivity of some of the CITs.

Linder and colleagues (2012; 2013) propose that though autonomy is key to allowing inquiry teams to try out ideas and adjust learning approaches, support and guidance in the form of skilled facilitation promotes productive engagement in inquiry and knowledge development. Facilitators, unlike traditional trainers who simply transmit information, serve as a source of motivation and encouragement by sustaining discourse norms, posing open or hypothetical questions, emphasizing similarities and differences between diverse perspectives, and clarifying key points (Bangert, 2008; Booth, 2012; Crespo, 2006; Henderson, 2007).

In addition to guiding productive discussions and helping teams maintain focus, Booth (2012) and Caudle (2013) propose that facilitators also serve as caretakers helping to build alliances, establish trust, support cohesion, and provide encouragement. A facilitators' strong and active presence is especially important during inquiry around critical issues of practice that may involve challenging interactions as individual push each other's thinking and raise differing and often contradictory perspectives.

Having a facilitator present at team Y's September meeting appears to have supported the development of clear norms and expectations for future interaction. The team relied on these structures and agreements throughout their inquiry work, including having an assigned facilitator for each meeting who was responsible for establishing an agenda and monitoring progress throughout the meeting. Team X also designated a facilitator for each meeting and followed a set agenda. Both of these teams progressed to a high-functioning stage of critical colleagueship. Neither team Z nor team W progressed past an intermediate stage of critical colleagueship. Neither of these teams assigned roles at meetings nor developed or followed an agenda, although these were structures included in their team charter. This study evidence supports findings from other empirical studies connecting skilled facilitation of structured discussions and the productive, interdependent collaborative inquiry of high-functioning teams (Henderson, 2007; Kintz et al., 2015; Nelson et al., 2008). It thus appears that although autonomy around goal setting and meeting content promotes agency and efficacy, facilitative guidance and clear meeting structures help promote critical colleagueship and team productivity.

Using shared referents and protocols. Team discussions in the beginning stages of critical colleagueship are characterized by egocentric and often disconnected contributions that are general in nature and often peripheral to daily teaching and learning. On the other hand, those of teams with high-functioning critical colleagueship involve active investigation of diverse perspectives through elaboration and probing of ideas grounded in specific teaching and learning incidents or shared referents (van Es, 2012). Males, Otten, and Herbel-Eisenmann (2010) propose that reliance on personal stories as evidence for claims and ideas limits critical discourse because individuals can fall back on agreeing to disagree based on differing personal experience. They also propose that it is more difficult for individuals who are developing collegial trust to challenge personal practice than to discuss ideas from outside sources, such as readings, or shared experiences, such as participating in instructional rounds or watching a video of classroom instruction, as the latter may feel safer and less personal.

The use of shared referents or artifacts, such as student work, case studies, or classroom videos, promotes collaborative dialogue and helps shift the conversation away from external factors, which in turn promotes stronger collective efficacy for teaching (Crespo, 2006; Nelson, Perkins, & Hathorn, 2008). Additionally, close examination of shared referents promotes active participation and supports educators' noticing ability, as well as the development of collective vocabulary and expectations (Barnes & Solomon, 2014; Croft et al., 2010).

Study participants, guided by the MISSL, participated in instructional rounds at the host school for their monthly in-person meeting throughout the study. Although participating in instructional rounds was not part of the study design, observations from these rounds served as shared referents during many of their CIT discussions, as coaches made connections to their goals, "small wins," and personal practice. One example was this exchange from team Z's September in-person meeting as they worked to clarify their definition of student engagement based on what they had seen that morning during instructional rounds:

> *Z2: The collab lab was time for them to do the problem together and share their responses. But instead everyone did a different problem and there was no talking. So, that's why I'm saying that there is a lot more that goes into talking … Student engagement is student engagement. It's basically everybody's goal in the whole*

district. So, I thought I saw a lot of student engagement today. They were taking notes, they were on Dreambox, they were engaged, but are we talking about student-student discourse as engagement?

Z1: It's interesting that you say that because when I was walking in I was looking for the student-student discourse as engagement.

Z3: That's what I was looking for too.

Z2: And I was too, but that doesn't mean that they aren't engaged. I've also heard [the district's curriculum director] *say several times that we're targeting individual learners.*

Z3: Right, but I was looking at it from the lens that it was student-student or student-teacher discussion when I was going in there looking for that, but as you're saying there were also students that were really working on the computer or working on problems.

Z1: There were some with scrap paper really working on it.

Z3: Right so there were some that were really working at it. I saw students doing independent work completing a worksheet but are they really getting a lot out of that? They were sitting there quietly but were they really engaged?

Z2: And why weren't they sitting together?

Z3: Right why were they sitting alone? Why weren't they talking to each other about the problems?

Z1: I almost think we're all taught when people come in to observe the class you have to be on your best behavior and be quiet. But sometimes a noisy classroom is *a good classroom. Then discourse is happening. Not just quiet with everyone on task.*

Z3: Yeah, I always think that when people say oh the kids are so well behaved. Sure, they might be quiet but let's look at what they are doing. What are they learning?

In addition to observations from instructional rounds, teams also made use of data from collaboratively designed classroom observation tools and videos of classroom instruction. Beginning at their November in-person meeting, team Y structured their discussions around multiple shared referents and protocols, including classroom videos, a dilemma consultancy protocol (see Appendix O), and shared lesson debriefs. Discussions at this and subsequent meetings moved from a beginning-intermediate stage to an intermediate-high-functioning stage, an indication that the use of structures such as shared referents and protocols support critical colleagueship development and higher quality discussions, especially in the absence of skilled facilitation. Kintz and colleagues (2015) support this notion, proposing that reflective dialogue around specific classroom events and/or student work leads to deeper development of ideas and is a necessary condition for critical colleagueship development.

Promoting a positive team culture. Collegial trust, a key element of both C-MEFT and ISC, allows individuals to "feel safe to make mistakes, discuss them, learn from them, and then find ways to solve problems" (Lee, Zhang, Yin, 2011, p. 827). In a collaborative learning community, individuals must trust not only the people involved, but also the learning process and systems supporting their learning. Developing a team charter at the beginning of the learning process promotes collegial trust and provides an opportunity for team members to determine how to best work together, including determining measures of accountability and norms for social interaction (Anderson, 2008; Servais, Derrington, & Sanders (2009). As team Y found in this study, not taking the development of a charter seriously at the beginning of the CIT process led to problems with individuals not feeling valued and lacking a sense of how to move forward as an effective team. The detailed operating norms team Y developed during its September meeting were referred to at every subsequent meeting and promoted rapport and collegial trust as all members knew what was expected of themselves and others. This provides evidence for Servais and colleagues (2009) proposition that "developing a set of operating norms is an important first step to guide the [collaborative inquiry] process and assure accountability to the team" (p. 8) as members work to develop relationships and build a foundation of trust and support.

Limitations

The observational nature of this study's one-group, pre-test-post-test design has limited statistical power to determine causal relationships (Shadish et al., 2002), but still provided information regarding the interventions' effect on the size and direction of the relationship between critical colleagueship development and C-MEFT and ISC perceptions. Although experimental designs, such as quasi-experimental and randomized control trials, have greater power and stronger validity, the contextual constraints of this study limited the evaluation designs that could be employed. Needs assessment data and an examination of literature indicated the intervention should target the district's elementary mathematics coaches and MISSL, as school based instructional leaders (Friedman, 2011; Nappi, 2014; Spillane, Hopkins, & Sweet, 2015), limiting the potential population size to 21. With a goal of developing stronger inter-school professional support networks, it was important that all participants be involved in the treatment, a condition also mandated by the district. Given this small population size and without a control group, a one-group, non-experimental design was the most viable option (Shadish et al., 2002).

The absence of a control group and the small sample size produce numerous potential threats to both internal and statistical conclusion validity (Shadish et al., 2002). Recognizing these potential threats to validity, a larger embedded, mixed methods design was employed to provide additional data sources and analysis strategies, thus improving the overall design (see evaluation matrix Appendix G; Creswell & Clark, 2011). Additionally, specific threats, including participant heterogeneity and history, implementation fidelity, and measurement validity were carefully considered during the design process to increase the evaluations' explanatory power and the likelihood of finding a plausible connection between existing effects and the intervention, as opposed to extraneous factors (Rossi, Lipsey, & Freeman, 2004; Shadish et al., 2002; Wholey et al., 2010).

The small population size precluded determining statistical correlations, so triangulation of quantitative and qualitative data was used to explain plausible patterns of relationships (Rossi et al., 2004) between engagement, critical colleagueship development, and C-MEFT and ISC perceptions, but was limited by lack of implementation fidelity. As described earlier, none of the CITs had high fidelity in terms of dose delivered or dose received. Specifically, skilled facilitation, establishment of clearly defined goals for overall work and individual meetings, and explicit opportunities for relationship building, all conditions associated with critical colleagueship development and promotion of positive C-MEFT and ISC perceptions (Cosner, 2009; Kintz et al., 2015; Servais et al., 2009) were all components of the original intervention design that were not implemented as intended due to meeting time and personnel constraints.

Determining whether these three CIT design features influence critical colleagueship, C-MEFT, or ISC outcomes will require additional research that both ensures and controls for implementation of these design features. Future research should investigate the mediating impact of (a) skilled facilitation, (b) explicit team building activities, and (c) on critical colleagueship development and resulting C-MEFT and ISC perceptions. Additionally, research should examine the role of skilled facilitation on the development of clearly defined and measurable collaborative inquiry goals, as well as the impact of the quality of these goals on critical colleagueship, C-MEFT, and ISC outcomes.

Implications for Practice

Organizational change, including development of effective professional learning systems, occurs incrementally by changing one aspect at a time over many years (Jensen et al., 2016; Kotter, 1995). Kotter (1995) proposes eight key steps for promoting organizational change. These include: forming a powerful guiding coalition, establishing and communicating a clear vision, empowering individuals to act upon the vision, and planning for and creating short-term wins. The following are suggestions for incremental changes, based on Kotter’s key steps, findings from this study, and other existing empirical evidence.

Forming a powerful guiding coalition. High-performing systems are bottom-up systems that have clear, prescriptive expectations of what constitutes quality professional learning established from central administration and distributed across three levels of instructional leadership: peer leaders (such as mathematics coaches) within schools, system leaders of professional learning (such as the district-wide MISSLs), and principals to ensure professional learning aligns to school improvement plans (Loucks-Horsley & Matsumoto, 1999). This study was designed with distributed leadership in mind. The school-based mathematics coaches were targeted due to their potential for creating schoolwide cultures of collaboration and peer support, as they work to connect district professional development goals with classroom practices and needs (Killion et al., 2012). Beginning with small, inter-school teams comprised of school-based instructional leaders, such as mathematics coaches, creates initial capacity for self-determined inquiry and helps build a powerful guiding coalition that can be expanded in subsequent years to include more educators, with the members of these original teams as facilitators for either intra- or inter-school teams (Kotter, 1995; Nelson et al., 2008).

A drawback to this study's design was the lack of a clear plan for including school principals, a key stakeholder identified by Loucks-Horsley and Matsumoto (1999), in the planning or implementation of the CIT process. Although Kotter (1995) proposes that not all administrators in an organization need to be part of the change guiding coalition, a lack of buy-in from principals can impede collective efficacy for teaching development by negatively influencing teachers' collaborative work (Goddard, Goddard, Kim, & Miller, 2015). This appears to have been the case for some of the CITs in this study as evident in statements such as: *probably if my principal supports this then it* [the team's plan for classroom observations] *can run but I have to get his permission first* (Z4; team Z October in-person meeting) and *like the other day, my principal wanted me to do something else when we were supposed to be meeting, so that makes it really hard* (W2, team W November in-person meeting), where coaches felt their school's principal was a barrier to accomplishing CIT work. In contrast, statements such as, *I feel way more comfortable about it* [using the team's classroom observation tool] *now that my principal sees this as more connected to what we're* [the school's leadership team] *doing* (X6, team X December in-person meeting) indicate coaches felt more confident in their ability to accomplish CIT work and goals when their principals understood and supported that work.

Taking time throughout the collaborative inquiry process to not only align CIT work to school and district priorities, but to also clearly communicate CITs goals and action plans with school principals may have helped facilitate team progress through an expanded guiding coalition and supportive conditions (Kotter, 1995).

Creating and communicating a clear vision. Kotter (1995) proposes that organizational transformation is often impeded by a team's failure to either clearly establish a vision of change processes and goals and/or failure to effectively communicate this vision to other organizational stakeholders. In this study, each CIT established a long-term goal based on mathematics teaching and learning data that aligned to school and district priorities (see table 5.1). These goals all connected to the district's mission of promoting student-centered mathematics instruction, alignment that is important for change implementation (Eyal & Roth, 2011; Faraj et al., 2015; Minckler, 2014; Valli & Buese, 2007). The establishment of a clear, cohesive vision is only the first step as it must be followed by effective communication. Kotter (1995) suggests this is best accomplished by leveraging all available channels of communication, including incorporating messaging into daily activities and conversations, as he explains, "communication comes in both words and deeds, and the latter are often the most powerful form" (p. 6).

This means it is important for all stakeholders, in this study the elementary mathematics coaches and elementary MISSL, as well as district administrators, to clearly communicate what student-centered mathematics instruction looks like and why it is important throughout their daily practice. Karp and colleagues (2016) espouse that creating a cohesive vision for mathematics instruction, "is not unlike a school-wide behavior management policy – where children hear the same phrases, identical expectations are shared, and practices are common and consistent year after year across classrooms and the school" (p. 61). Having a common vision for effective mathematics instruction also supports instructional consistency across classrooms, provides a solid foundation upon which mathematics teaching and learning can build, and promotes professional collaboration as all educators work toward a shared vision for effective instruction.

Collaborative inquiry, such as that which framed this study's intervention, supports the development of a cohesive vision through successive cycles of dialogue and implementation, deepening understanding of what effective student-centered mathematics instruction looks like and refining understanding of related terminology, such as engagement and discourse. All four CITs in this study engaged in clarifying dialogue during meetings. For example, at their September in-person meeting, team Z discussed the meaning of student engagement as they connected observations from instructional rounds to the action plan goal development:

> *Z2: Student engagement is student engagement. It's basically everybody's goal in the whole district. So, I thought I saw a lot of student engagement today. They were taking notes, they were on Dreambox, they were engaged. But are we talking about STUDENT-TO-STUDENT discourse as engagement?*
>
> *Z1: It's interesting that you say that because when I was walking in I was looking for the STUDENT-TO-STUDENT discourse as engagement.*
>
> *Z3: That's what I was looking for too.*
>
> *Z2: And I was too, but that doesn't mean that they aren't engaged.*
>
> *Z1: Right, but I was looking at it from the lens that it is STUDENT-TO-STUDENT or STUDENT-TO-TEACHER discussion when I was going in there looking for that, but as you're saying there were also students that were really working on the computer or working on problems.*

Z3: There were some with scrap paper really working on it.

Z1: Right so there were some that were really working at it. I saw students doing independent work completing a worksheet but are they really getting a lot out of that. They were sitting there quietly, but were they really engaged?

Team X also discussed the meanings of student engagement and discourse during their December in-person meeting as they worked to revise their classroom observation tool:

X1: The other thing about the tool is that we may need to better define what we mean by engagement. We need to start defining engagement based on what students are doing, that's why I liked your discussion the other day, because engagement doesn't have to be all talking. They can be having discussions sharing pictures and all this other stuff to show their thinking. But if you're just looking for engagement if there are students doing independent work and they're fully focused on it then they're engaged.

X4: Well engagement and student-to-student discourse are two totally different things.

X1: Right, but that tool goes back and forth.

X4: It does. But you know on the last, um, one thing I learned from our hangout and from instructional rounds is that discourse can be done in multiple ways. It can be done whole group, it can be done with partners, it can be done in lots of different ways.

X5: Maybe we need to have more of a conversation about what X1 is saying. What are we looking at? Are we looking at engagement? Are we looking at *student-to-teacher discourse? Or are we really going to make the focus student-to-student discourse?*

X1: And even with student-to-student discourse, and I'm probably over thinking it, but student-to-student discourse when you start thinking in rubric terms, because you want to be consistent in what you observe, you have to have sort of a definition of these components. And I think without discussing it, that our definitions may be different and that's why we keep saying that we're uncomfortable with the wording of the tool.

X3: Right, so if we're developing it [the tool]*, isn't this a good time for an edit?*

X6: You mean to define what is engagement or what types of engagement we're looking at or something like that?

Several coaches also mentioned bringing these clarifying discussions back to their schools through conversations with classroom teachers and school-based literacy coaches. For example, one member of team X stated, *what the literacy coach and I did was had a conversation with each grade level team. And we talked about what they thought discourse was before they did anything, then we showed them a few videos, and then we set up a space in classroom for them to share their thoughts and then they each shared with our instructional leadership team their definition of discourse and we pulled those altogether as a shared definition for the school* (X4, December in-person meeting).

Promoting professional conversations, like these, around terminology serve as vehicles for communicating visions for change as educators within and across schools come to consensus around expectations for high-quality mathematics teaching and learning. This school and/or district wide clarity can then enable instructional leaders to develop and enact a strategy for supporting both students and educators (Kotter, 1995). When this improvement process is team based and inquiry focused, it promotes “a progressive cycle, in which each successive cycle leads to better and deeper understanding, more refined practices, and greater impact on student learning and achievement” (Donohoo & Katz, 2017).

Empowering others to act on the vision. Kotter (1995) proposes that effective communication of a clear vision, though vital, is not sufficient for promoting change success, as organizational structures and systems can still impede progress. As mentioned earlier, leaders play a big role in promoting vision achievement through their actions, which must include removing potential barriers to collaborative inquiry and individual empowerment (Donohoo & Katz, 2017; Kotter, 1995).

One barrier to sustained, job-embedded collaborative learning identified both in this study and other empirical studies (Calvert, 2016; Hamann, Lane, & Johnson, 2001; Jensen et al., 2016) is time. This includes time for collaboration and time to experiment with new ideas and strategies within daily practice. Calvert (2016) proposes that rethinking schedules to provide time for regular collaboration promotes teacher agency as they feel both valued and empowered. The coaches at some of the schools were not supported when trying to implement their CIT work at their buildings, leading to the use of time and lack of principal buy-in as excuses for not fully engaging in their collaborative work. Involving principals in the CIT planning and more clearly communicating the vision and process for this work may have alleviated barriers related to the implementation of multiple initiatives, making time for CIT work a priority within each school’s professional development plan.

Regular time for meeting both in-person and virtually was built into this study’s schedule and CIT goals were aligned to school improvement plans to allow the mathematics coaches to incorporate their CIT work within their daily work. However, time related barriers were still discussed in almost one-half of CIT discussions (11 out of 23 meetings). Additionally, in monthly feedback surveys several coaches asked for more time to meet in-person and to visit each other's schools as they worked to develop a clearer conception of each other's contexts. Incorporating monthly opportunities for CIT members to meet at schools on a rotating basis with time to both observe classrooms and meet to discuss practice implications could serve to further promote collaboration and change practices. Alternatively, classroom videos could be shared online through secure channels within Google classroom with opportunities for CIT members to collaboratively view and reflect on classroom-based artifacts without needing to travel to school sites. Video blogging and podcasting could also be used for team members to pose questions and receive resources or share specific experiences and receive additional ideas and feedback (Croft et al., 2010). These increased opportunities for shared practice would also likely strengthen C-MEFT and ISC perceptions through vicarious learning and a shared sense of collective success (Donohoo & Katz, 2017).

Planning for and creating short-term wins. Changed practice takes time. Kotter (1995) proposes that "renewal efforts risk losing momentum if there are no short-term goals to meet and celebrate" and that "without short-term wins, too many people give up or actively join the ranks of those people who have been resisting change" (p. 6). This phenomenon was evident in this study. After establishing a long-term goal, expected to be achieved by the end of the school-year, teams developed three "small-wins" to promote goal achievement, however a lack of skilled meeting facilitation resulted in both ambiguity around how "small win" success would be determined as well as some "small wins" being more activity focused than inquiry based. This diverted time, energy, and resources away from a student learning focus and impeded the overall collaborative inquiry process (Donohoo & Katz, 2017), leaving some coaches frustrated and feeling unclear as to whether progress had been made. For example, one member of team Z commented, *I'm not sure if we accomplished our goals because we didn't have clear outcomes. We did have a good conversation and were engaged in the work, just not clear outcomes* (Z4, December monthly feedback survey).

On the other hand, team X, which established measurable goals directly connected to classroom-based inquiry were able to use those "small wins" to help maintain momentum. This can be seen in a portion of their November in-person meeting, where after spending time discussing frustration they were feeling around not being able to accomplish as much of their CIT work as they wanted (*…things keep filtering in that are taking away this coveted time and I feel like I don't have time for what I want to be doing…*), they looked at the three "small wins" on their action plan and realized they had made progress:

> *X5: So, let's look at where we are with small win #1* [creating an observational tool] *and we're at the very end of it – at least most of us. And for small win #2* [trying out the tool and then revising it]...
>
> *X1: We already accomplished that…*
>
> *X5: Right we're actually into small win #3* [using the tool to collect data in classrooms in support of their instructional coaching with teachers]
>
> *X2: Oh, okay. I see.*
>
> *X1: So, we're not where we wanted to be as individuals, but as a team we're right where we planned to be at this point.*
>
> *X2: Oh, that's good. Wow. That's awesome. That's kind of validating.*

X6: Oh right, we have. It just doesn't feel like it because we haven't all gotten to use it yet, but that's not until win #3. Oh, that's good.

It appears, as Kotter (1995) and Donohoo and Katz (2017) suggest, team X's recognition of "small win" achievement served as motivation to stay committed to achieving their larger vision as a collaborative unit, despite day-to-day challenges being faced at their schools. Having a skilled facilitator at CIT meetings likely would have helped all of the teams "stay focused on urgent, needs-based inquiry questions" (Donohoo & Katz, 2017, p. 26) and specific, measurable "small-wins" that would promote the mastery experiences associated with enhanced C-MEFT.

Final Thoughts

Organizational capacity building in K-12 schools refers to the development of the collective abilities of educators across schools to promote both student achievement and professional learning (Andrews & Lewis, 2004). As this study's conceptual framework (see Figure 5.10) lays out, schools' mathematics teaching and learning capacity is influenced by four categories of factors: professional support networks, contextual factors, educators' mathematics knowledge for teaching (MKT), and educators' mathematics efficacy for teaching (MEFT). Because schools are social learning organizations, environmental conditions and structures that enhance inter-school and intergroup professional network development and communication (see contextual factors in Figure 5.10) are key to increasing resource exchange capacity (Andrews & Lewis, 2004; Leana, 2011; Minckler, 2014) and for the reflective, collaborative dialogue and discourse needed to promote collective learning and perceptions of C-MEFT.

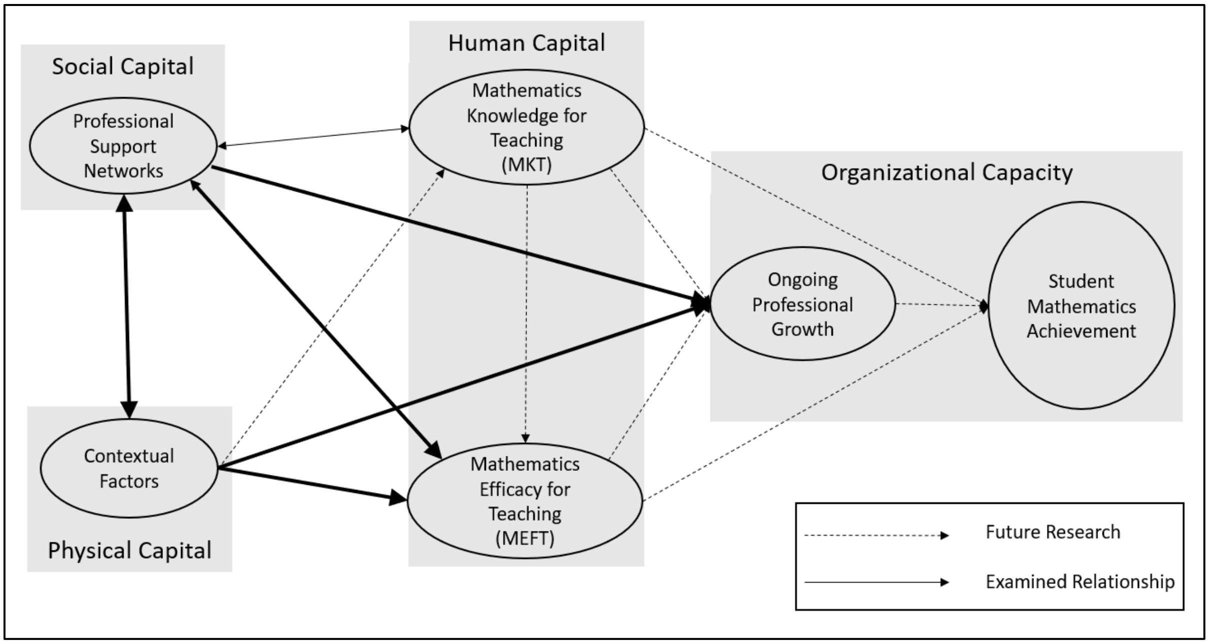


Figure 5.10. Conceptual framework showing examined relationships and areas for future research.

This study examined the impact of engaging elementary mathematics coaches, key school-based instructional leaders, in structured collaborative inquiry on the development of the district's capacity to promote collective accountability for effective mathematics teaching and learning across its 21 elementary schools. Success analysis focused on examining connections between actual and perceived professional support network development (social capital); contextual factors such as time, policies, and resources (physical capital); and collective mathematics efficacy for teaching perceptions (human capital; see solid arrows in Figure 5.10). Although results cannot be conclusively tied to the intervention itself, statistical analysis and anecdotal evidence suggest positive changes to these coaches' C-MEFT and ISC perceptions are connected to strengthened inter-school, professional support networks and the deprivatization of practice. Coaches shared school-based experiences and artifacts, sought out additional opportunities to interact, and expressed enhanced appreciation for commonalities and differences across school contexts. This shift appears clear in this statement by a member of team Y at the final meeting in February:

> *I was really hesitant at first to both use Google and to work with my team. To be honest, I figured I'd just continue to do my own thing. But this past Google Hangout was probably our most productive meeting yet. We're really getting on as a team and helping each other get some really good work done. I'm also starting to use Google in other parts of my work. It just makes things so much easier (Y1).*

Overall, findings indicate focusing future professional development efforts, especially for school-based instructional leaders, on promoting social capital, in addition to human capital, may be an effective approach to promoting organizational capacity in terms of students' mathematics achievement and educators' ability to support their own ongoing professional learning. Additionally, findings indicate that although autonomy and empowerment are enabling conditions for collective efficacy and professional cohesion (Donohoo, 2017; Eyal & Roth, 2011; Rock & Cox, 2012), effective collaborative and sustainable professional learning opportunities also require alignment to existing district priorities, team building structures and opportunities, clear communication of process and outcomes, and skilled facilitation to ensure focus, equitable engagement, and sustained impact. In other words, there appears to be a strong inter-relationship between contextual factors, professional support networks, and collective efficacy for teaching (see Figure 5.10).

The six-month time frame and small number of participants in this study precluded an examination of the impact of changes to professional support networks, contextual factors, or collective mathematics efficacy for teaching on ongoing professional growth or students' mathematics achievement. Determining these distal effects of sustained participation in collaborative inquiry teams is an important area for future research, as enhanced organizational capacity was the intervention's long-term goal or intended impact (see Figure 4.1). Additionally, participants' mathematics knowledge for teaching (MKT), a key underlying factor in organizational capacity building (see Figure 5.10), was not examined as part of this study's design. Because the depth and breadth of educators' MKT has been found to influence students' mathematics achievement (Ball et al., 2008; Ma, 2010), educators' C-MEFT (Hill, 2010; Smith et al., 2005), and the impact of professional support networks on ongoing professional growth (Coburn & Russell, 2008), examining the influence of sustained participation in collaborative inquiry should also be an area of future research. In closing, further examination of the proximal and distal impact of collaborative inquiry team engagement on key factors of social, physical, and human capital within this school district and others, will provide an enhanced understanding of whether providing elementary mathematics coaches increased opportunities to engage in purposeful conversations and authentic inquiry around student performance strengthens C-MEFT and ISC perceptions and ultimately leads to stronger organizational capacity for student and teacher support and success (see Figure 5.10; Figure 3.2).

Appendix A

Mathematics Efficacy for Teaching Survey

Dear Teachers and Coaches,

I am a doctoral student in Instructional Design for Online Teaching and Learning in the School of Education at Johns Hopkins University. As a fellow educator, I am very interested in learning more about what personal and structural factors influence a teacher's ability to meet the needs of elementary students in mathematics classrooms.

This survey should take no more than 15 minutes to complete. Responses are completely confidential. Please place the completed surveys in the envelope labeled for your school when you are finished.

At the end of the survey, I will ask if you'd like to participate in the next part of the study, which includes a second survey and a possible confidential interview. If you're interested, please provide your name and email address so I can contact you to discuss the study further. If you're not interested, you can leave that request blank.

Should you have any questions, please call me at (401) 855-1198 or email me at sdonald7@jhu.edu. All of our communications will be confidential.

Thank you very much for your time and thoughtfulness!

Sara Donaldson

Which grade(s) do you currently teach or work with?

- 3
- 4
- 5
- Other: ___________________

Including this year, how many years have you been teaching full time?

- 1-3
- 4-6
- 7-11
- 12-20
- Over 20
- Other: __________________

Including this year, how many years have you been in your present position (grade and school)?

- 1-3
- 4-6
- 7-11
- 12-20
- More than 20
- Other: __________________

Thank you so much for completing this survey!

Teacher Beliefs: Part 1

Directions: Please indicate your opinion about each of the statements below. Your answers are confidential.

	Strongly Disagree		Disagree		Uncertain		Agree		Strongly Agree
I continually find better ways to teach mathematics.	1	2	3	4	5	6	7	8	9
I am not able to teach mathematics as well as I teach most subjects.	1	2	3	4	5	6	7	8	9
I know how to teach mathematics concepts effectively.	1	2	3	4	5	6	7	8	9
I am not very effective in monitoring mathematics activities.	1	2	3	4	5	6	7	8	9
If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	1	2	3	4	5	6	7	8	9
The inadequacy of a student's mathematics background can be overcome by good teaching.	1	2	3	4	5	6	7	8	9
I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	1	2	3	4	5	6	7	8	9
Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	1	2	3	4	5	6	7	8	9
I find it difficult to use manipulatives and other models to explain to students why mathematics works.	1	2	3	4	5	6	7	8	9
I am typically able to answer students' questions.	1	2	3	4	5	6	7	8	9
I have the necessary skills to teach mathematics.	1	2	3	4	5	6	7	8	9
Given a choice, I do not invite the principal to evaluate my mathematics teaching.	1	2	3	4	5	6	7	8	9
When a student has difficulty understanding a mathematics concept, I am usually at a loss as to how to help the student understand it better.	1	2	3	4	5	6	7	8	9
When teaching mathematics, I usually welcome student questions.	1	2	3	4	5	6	7	8	9
I do not know what to do to turn students on to mathematics.	1	2	3	4	5	6	7	8	9

Teacher Beliefs: Part 2

Directions: Please indicate your opinion about each of the statements below. Your answers are confidential.

	Strongly Disagree		Disagree		Uncertain		Agree		Strongly Agree
Teachers in this school really believe every child can learn mathematics.	1	2	3	4	5	6	7	8	9
Teachers in this school are able to get through to difficult students in math.	1	2	3	4	5	6	7	8	9
Teachers at this school don't have the skills needed to produce meaningful student learning in mathematics.	1	2	3	4	5	6	7	8	9
Teachers here need more training to know how to deal with students who are struggling in mathematics.	1	2	3	4	5	6	7	8	9
Teachers at this school are well-prepared to teach mathematics.	1	2	3	4	5	6	7	8	9
If a child doesn't learn something in math the first time teachers will try another way.	1	2	3	4	5	6	7	8	9
Teachers in this school think there are some students that no one can reach.	1	2	3	4	5	6	7	8	9
Teachers in this school are skilled in various methods of teaching mathematics.	1	2	3	4	5	6	7	8	9
The lack of instructional materials and supplies makes mathematics teaching very difficult.	1	2	3	4	5	6	7	8	9
Teachers here are confident they will be able to motivate their students in math.	1	2	3	4	5	6	7	8	9
Homelife factors keep students at this school from learning math at a high level.	1	2	3	4	5	6	7	8	9

I'm looking for teachers for the next part of the study, which will consist of a brief second survey and a possible follow-up interview. If you're interested, please write your name and email address (or phone number, if you prefer) below. All responses will be kept anonymous.

______________________________ Name

______________________________ Email address (or phone number)

Appendix B

Professional Support Networks Survey

Support Networks

Below list up to five individuals from whom you have sought advice or information about math teaching strategies or content. For each person please indicate his/her relationship to you, how frequently you seek advice from the person, how influential this person's advice was on your practice, and the type of advice was shared.

Person 1:

Relationship (choose 1):

- o teacher from my grade level team
- o teacher from a different grade level at my school
- o teacher from a different school
- o math coach
- o special educator
- o principal or assistant principal
- o district math specialist
- o other (please specify): ____________________

What type of advice or information did you seek from this person? (Choose all that apply):

- o deepening your content knowledge
- o planning or selecting course content and materials
- o approaches for teaching content to students
- o strategies specifically to assist low-performing students
- o assessing students' understanding of the subject
- o other: ____________________________________

How frequently did you seek advice or information from this person?

Daily	Weekly	Monthly	Quarterly	Yearly
1	2	3	4	5

How influential was this person's advice on your own practice?

Very Influential				Not Influential
1	2	3	4	5

Person 2:

Relationship (choose 1):

- o teacher from my grade level team
- o teacher from a different grade level at my school
- o teacher from a different school
- o math coach
- o special educator
- o principal or assistant principal
- o district math specialist
- o other (please specify): ____________________

What type of advice or information did you seek from this person? (Choose all that apply):

- o deepening your content knowledge
- o planning or selecting course content and materials
- o approaches for teaching content to students
- o strategies specifically to assist low-performing students
- o assessing students' understanding of the subject
- o other: ____________________________________

How frequently did you seek advice or information from this person?

Daily	Weekly	Monthly	Quarterly	Yearly
1	2	3	4	5

How influential was this person's advice on your own practice?

Very Influential				Not Influential
1	2	3	4	5

Person 3:

Relationship (choose 1):
- o teacher from my grade level team
- o teacher from a different grade level at my school
- o teacher from a different school
- o math coach
- o special educator
- o principal or assistant principal
- o district math specialist
- o other (please specify): ____________________

What type of advice or information did you seek from this person? (Choose all that apply):
- o deepening your content knowledge
- o planning or selecting course content and materials
- o approaches for teaching content to students
- o strategies specifically to assist low-performing students
- o assessing students' understanding of the subject
- o other: ___________________________________

How frequently did you seek advice or information from this person?

Daily	Weekly	Monthly	Quarterly	Yearly
1	2	3	4	5

How influential was this person's advice on your own practice?

Very Influential				Not Influential
1	2	3	4	5

Person 4:

Relationship (choose 1):
- o teacher from my grade level team
- o teacher from a different grade level at my school
- o teacher from a different school
- o math coach
- o special educator
- o principal or assistant principal
- o district math specialist
- o other (please specify): ____________________

What type of advice or information did you seek from this person? (Choose all that apply):
- o deepening your content knowledge
- o planning or selecting course content and materials
- o approaches for teaching content to students strategies
- o specifically to assist low-performing students assessing
- o students' understanding of the subject other:
- o ___________________________________

How frequently did you seek advice or information from this person?

Daily	Weekly	Monthly	Quarterly	Yearly
1	2	3	4	5

How influential was this person's advice on your own practice?

Very Influential				Not Influential
1	2	3	4	5

Person 5:

Relationship (choose 1):
- o teacher from my grade level team
- o teacher from a different grade level at my school
- o teacher from a different school
- o math coach
- o special educator
- o principal or assistant principal
- o district math specialist
- o other (please specify): ____________________

What type of advice or information did you seek from this person? (Choose all that apply):
- o deepening your content knowledge
- o planning or selecting course content and materials
- o approaches for teaching content to students strategies
- o specifically to assist low-performing students assessing
- o students' understanding of the subject other:
- o ___________________________________

How frequently did you seek advice or information from this person?

Daily	Weekly	Monthly	Quarterly	Yearly
1	2	3	4	5

How influential was this person's advice on your own practice?

Very Influential				Not Influential
1	2	3	4	5

Appendix C

Mathematics Coaches' Questionnaire

<table>
<tr>
<td>
At which school do you currently work?
o Blue
o Purple
o Red
o Yellow
o Green
o Orange
o Brown
o Other: _______________
</td>
<td>
With how many teachers do you currently work?
<table>
<tr><th>Grade</th><th># of Teachers</th></tr>
<tr><td>K</td><td></td></tr>
<tr><td>1</td><td></td></tr>
<tr><td>2</td><td></td></tr>
<tr><td>3</td><td></td></tr>
<tr><td>4</td><td></td></tr>
<tr><td>5</td><td></td></tr>
</table>
</td>
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</table>

1. How were you chosen for your position at your present school? ***(Choose all that apply.)***
    - o I was chosen by the principal from an internal pool of applicants
    - o I was chosen by the principal from an external pool of applicants
    - o I was assigned to my school by someone in the district other than the principal
    - o Other: ___________________________________

2. What would you say are your most important roles as the math coach at your school? ***(Choose up to five.)***
    - o Supporting classroom teachers with math instruction in their classroom
    - o Providing professional development opportunities for teachers
    - o Coordinating benchmark assessments and data analysis in mathematics
    - o Supporting small groups of students who are struggling in mathematics
    - o Acting as a liaison between the school and the district administration
    - o Acting as a liaison between the school and other schools in the district
    - o Serving as part of the school's leadership team
    - o Providing administrative support throughout the building (not always math related)
    - o Helping to develop and carry out our school improvement plan
    - o Coordinating district-wide mathematics initiatives

3. Which statement ***best*** describes the materials/programs and instructional strategies teachers at your school use for math instruction?
    - o Teachers are required to use the district approved mathematics program
    - o Teachers follow the district's standards-based mathematics framework using a variety of programs/materials
    - o Teachers use a combination of programs, materials, and strategies based on the needs of their students

- Other: ____

4. How much time is spent on math instruction in classrooms on a typical day?
   - 0-30 minutes
   - 30-60 minutes
   - 60-90 minutes
   - 90-120 minutes

5. How does this compare to the time spent on ELA?
   - More instructional time is spent on math than ELA
   - About the same amount of instructional time is spent on math as ELA
   - Less instructional time is spent on math than ELA

6. What are your biggest challenges when supporting math instruction in your school? (***Choose the top three)***
   - Teacher content knowledge
   - Teacher pedagogical knowledge
   - Teacher confidence
   - District constraints
   - Lack of available resources, such as curriculum programs or materials
   - Lack of cohesive curricular framework/standards
   - Student prior preparation
   - Negative attitudes toward mathematics
   - Other:________________________________

7. With whom or what resources do you consult for advice or knowledge about mathematics instruction?

8. With whom or what resources do you consult for advice or knowledge about coaching teachers?

9. Is there anything else related to delivering effective math instruction at your school that you think would be important for me to know?

Appendix D

District Mathematics Instruction School Support Liaison Questionnaire

Dear MISSLs,

I am a doctoral student in Instructional Design for Online Teaching and Learning in the School of Education at Johns Hopkins University. As a fellow educator, I am very interested in learning more about what personal and structural factors influence a teacher's ability to meet the needs of students in mathematics classrooms.

This survey asks you to provide some information about your position as a district mathematics instruction school support liaison and about math instruction in your district. The survey should take no more than 20 minutes to complete. Responses are completely confidential. Please return your completed survey to me via email when it is completed.

Should you have any questions, please call me at (401) 855-1198 or email me at sdonald7@jhu.edu. All of our communications will be confidential.

Thank you very much for your time and thoughtfulness!
Sara Donaldson

1. How long have you been a district math specialist? What was your job prior to taking this position?

2. Tell me about your job. (What work does your position involve? What percentage of your time is spent working with teachers, with coaches, with students, or with administrators?)

3. What are the priorities for your work? How are those priorities set?

4. How would you define the role and responsibilities of the school-based math coaches?

5. How are school based math coaches chosen?

6. What are the biggest challenges to math teaching in the district?

7. How do teachers and/or schools determine what materials, programs, and instructional strategies will be used for math instruction?

8. How do teachers and/or schools determine how students will be grouped for math instruction (ability, ELL, Special Education, heterogeneously, etc.)?

9. Who makes budgetary decisions related to math instruction at the district level? At the school level?

10. Besides Encore Math, are there other efforts underway related to improving math instruction and/or curriculum in the district or at individual schools? What are they? What are the goals of these efforts? Who oversees these efforts? What is your role in these efforts?

11. Do you collaborate with principals around math instruction related to their work with teachers? If so, describe that collaboration.

12. Do you collaborate with principals around the role and work of the math coaches at their schools? If so, describe that collaboration.

13. Do you notice or hear about instances of conflict between classroom teachers and math coaches or between math coaches and school principals? If so, what is the context for this conflict.

14. What else do you think would be important for me to know about the delivery of effective math instruction in your district?

Appendix E

School Principal Questionnaire

Dear Principals,

I am a doctoral student in Instructional Design for Online Teaching and Learning in the School of Education at Johns Hopkins University. I also have had the pleasure of working with the third, fourth, and fifth grade teachers in your school for the past year as a facilitator from Freedom University in the Encore in Math initiative. In collaboration with C.B., A.A., and J.M., I am focusing my doctoral research within the Libertyville Public Schools.

As a fellow educator, I am very interested in learning more about what personal and structural factors influence a teacher's ability to meet the needs of students in mathematics classrooms. I am hopeful that you will be willing to take 10-15 minutes to provide some information about math instruction at your school in support of this research.

By completing and returning the survey, you are indicating your willingness to participate in this study.

Should you have any questions, please call me at (401) 855-1198 or email me at sdonald7@jhu.edu. All of our communications will be confidential.

Thank you very much for your time and support!
Sara Donaldson

At which school do you currently work? o Blue o Purple o Red o Yellow o Green o Orange o Brown o Other: ______________________	Before you became a principal, what was your position? o Elementary classroom teacher o Middle school teacher in __________ (please list subject area) o High school teacher in ____________ (please list subject area) o Special educator Other: ___________________
Including this year, how many years have you been a principal? o 1-3 o 4-6 o 7-11 o 12-20 o Over 20	Including this year, how many years have you been a principal **at this school**? o 1-3 o 4-6 o 7-11 o 12-20 o Over 20

1. How was the math coach chosen for your school? *(Choose all that apply.)*
    - o I chose the coach from an internal pool of applicants
    - o External pool
    - o The coach was assigned to my school
    - o The coach was already working at the school when I became principal
    - o Other: ______________________________________

2. What would you say are the most important roles of the math coach at your school? ***(Choose up to five.)***
    a. Supporting classroom teachers with math instruction in the classroom
    b. Providing professional development opportunities for teachers
    c. Coordinating benchmark assessments and data analysis in mathematics
    d. Supporting small groups of students who are struggling in mathematics
    e. Acting as a liaison between the school and the district administration
    f. Acting as a liaison between our school and other schools in the district
    g. Serving as part of the school's leadership team
    h. Providing administrative support throughout the building
    i. Helping to develop and carry out our school improvement plan
    j. Coordinating district mathematics initiatives

3. Compared to other areas of teaching and learning, how comfortable are you supporting teachers in mathematics instruction? (***Choose one statement)***
    a. I am much more comfortable supporting math instruction than other subject areas
    b. I am more comfortable supporting math instruction than other subject areas
    c. I am just as comfortable supporting math instruction as other subject areas
    d. I am less comfortable supporting math instruction than other subject areas
    e. I am much less comfortable supporting math instruction than subject areas

4. Which statement ***best*** describes the materials/programs and instructional strategies teachers use for math instruction?
    a. Teachers are required to use the district approved mathematics program
    b. Teachers follow the district's standards-based mathematics framework using a variety of programs/materials
    c. Teachers use a combination of programs, materials, and strategies based on the needs of their students
    d. Other: ____
5. How much time is spent on math instruction in classrooms each day?
    a. 0-30 minutes
    b. 30-60 minutes
    c. 60-90 minutes
    d. 90-120 minutes

6. How does this compare to the time spent on ELA?
    a. More instructional time is spent on math than ELA
    b. About the same amount of instructional time is spent on math as ELA

c. Less instructional time is spent on math than ELA

7. What are the biggest challenges related to math instruction in your school? (***Choose the top three)***
    a. Teacher content knowledge
    b. Teacher pedagogical knowledge
    c. Teacher confidence
    d. District constraints
    e. Lack of available resources, such as programs or materials
    f. Lack of cohesive curricular framework
    g. Student preparation
    h. Negative attitudes toward mathematics
    i. Other:_______________________________

8. Do you work with the district mathematics instruction school support liaisons around math instruction at your school? If so, describe that collaboration?

9. Is there anything else related to math instruction at your school that you think would be important for me to know?

Appendix F

Email Content for Invitation to Participate in Part II of Needs Assessment Study

Dear (fill in teacher name),

Thank you for volunteering to provide some additional information for my study. This portion of the study involves a different survey that asks you to identify your relationship to individuals to whom you go for advice and support related to math instruction.

This survey should take no more than 15 minutes to complete. Responses are completely confidential. Please return the survey via email when it has been completed.

Should you have any questions, please call me at (401) 855-1198 or email me at sdonald7@jhu.edu. All of our communications will be confidential.

Thank you very much for your time and thoughtfulness!

Sara Donaldson
Doctoral Student in Instructional Design for Online Teaching and Learning
Johns Hopkins University
School of Education
sdonald7@jhu.edu
(401) 855-1198

Appendix G

Evaluation Matrix

	Research Questions	Variables	Data Sources	Frequency	Data Analysis
Outcome Evaluation	How does critical colleagueship influence perceptions of collective mathematics efficacy for teaching (C-MEFT)?	IV: Critical colleagueship (collab. Interactions, participation & discourse norms, & focus of activity or discussion) DV: C-MEFT (task analysis & group competency)	QUAL – transcripts from meetings & online interactions QUAN – Collective Efficacy for Teaching scale (Likert)	Monthly analysis using van Es' (2012) 3-stage rubric; Summarized at end of intervention Beginning of August (2017) PD day At final meeting (Feb 2018)	Coded using 3-stage rubric for community development - by conversation; analyzed over time by team Paired samples t-test (pre- & post-) – by individual to determine change ANOVA by team mean to be triangulated with critical colleagueship data to determine patterns
	How does critical colleagueship influence perceptions of internal social capital?	IV: Critical colleagueship (collab. Interactions, participation & discourse norms, & focus of activity or discussion) DV: Internal Social Capital (structural, cognitive, & relational capital)	QUAL – transcripts from meetings & online interactions QUAN – Internal Social Capital scale (Likert)	Monthly analysis using van Es' (2012) 3-stage rubric; Summarized at end of intervention Beginning of August (2017) PD day At final meeting (Feb 2018)	Coded using 3-stage rubric for community development - by conversation; analyzed over time by team Paired samples t-test (pre- & post-) – by individual to determine change ANOVA by team mean to be triangulated with critical colleagueship data to determine patterns
Process Evaluation	How does engagement in structured collaborative inquiry within a blended learning environment impact the degree of critical colleagueship amongst teams of mathematics educators over time?	IV (fidelity of intervention): Critical colleagueship (collaborative Interactions, participation & discourse norms, & focus of activity or discussion)	QUAL – transcripts from meetings & online interactions	Monthly analysis using van Es' (2012) 3-stage rubric Summarized at end of intervention	Coded using 3-stage rubric for professional community development (by conversation; analyzed over time by team)
	Which structures & systems of blended learning environ promoted & impeded critical colleagueship & active engagement?	Mediating Variable (fidelity of implementation): Engagement in collaborative inquiry process	QUAN/QUAL – feedback surveys & observations of work interactions; frequency tabulation of tool/structure usage; participation rates in different formats (in-person, video meetings, asynchronous collaboration) QUAN – critical colleagueship data analysis	Monthly analysis of transcripts, survey responses (Likert), frequency tabulations, & participation rates Summarized at end of intervention & correlated to critical colleagueship summary	Transcripts coded for mention specific tools/structures Survey responses – descriptive statistics Frequency tabulation - descriptive statistics by tool, month, & team Participation rates -descriptive statistics by format, month, & team Data will be triangulated to determine existing patterns.
	How did differing levels of engagement influence critical colleagueship development within teams?	Mediating Variable (fidelity of implementation): Engagement in collaborative inquiry process	QUAL/QUAN - Attendance records Frequency reports for online communications Feedback surveys QUAN – critical colleagueship data analysis	Monthly feedback survey analysis Monthly tabulations of participation (frequency of participation & attendance by indiv; % attendance by team at each meeting Summarized at end of intervention & correlated to critical colleagueship summary	Survey responses – descriptive statistics Descriptive statistics for attendance & participation (by individual & by team, over time) Data will be triangulated to determine existing patterns.

Appendix H

Collaborative Inquiry Team Action Planning Template

Action Plan for ________________________________

Long Term Goal(s):	Small-Win Strategy #1: Small-Win Strategy #2: Small-Win Strategy #3:

Small-Win Strategy #1:

Planned Work, Activities, and Tasks	Resources Needed	Timeline	Person(s) Responsible	Evidence of Success

Appendix I

Collaborative Inquiry Team Charter Template

Collaborative Inquiry Team Charter for

____

Team Member Names	Contact Information (email, cell, etc.)	Preferred Contact Method & Limitations (i.e.: no calls after…)
Team Member Names	Strengths related to teamwork & the team's chosen POP	Weaknesses related to teamwork and chosen POP

1. **What roles will each member have during and between meetings?** (Don't forget to include logistical tasks, such as arranging meetings, preparing agendas and meeting minutes, and keeping materials organized online; as well as team process roles, such as questioning, ensuring everyone's opinion is heard, etc.)

2. **When will your team hold its monthly Google Hangout meeting?** (Day and Time)

3. **What are your team's expectations regarding meeting attendance?** (Being on time, leaving early, missing meetings, etc.)

4. **What constitutes an acceptable excuse for missing a meeting or a deadline? What types of excuses are not considered acceptable?**

5. **What process will team members follow if they have an emergency and cannot attend a team meeting or complete their individual work/deliverable on time?**

6. **What are your team's expectations regarding the quality of team members' preparation for team meetings and the quality of the deliverables members bring to the team?**

7. **What are your team's expectations regarding team members' ideas, interactions with the team, cooperation, attitudes, and anything else regarding team-member contributions?**

8. **What methods will be used to keep the team on track?** (How will your team ensure that members contribute as expected to the team and that the team performs as expected? How will your team celebrate members who do well and manage members whose performance is below expectations?)

Adapted from CATME Smarter Teamwork tools http://info.catme.org/catme-tools/

Appendix J

Monthly Feedback Survey

Indicate approximately how often you performed each action as part of your inquiry team work over the past month (never, once or twice, weekly, almost daily):

- I communicated with team members through email
- I shared resources with team members through email
- I created a new Google Doc or Sheet on my own
- I collaborated with teammates using a Google Doc or Sheet
- I added new resources to a Google Drive folder
- I used resources someone else had shared on Google Drive
- I created a new folder on Google Drive and shared it with colleagues
- I participated a Google Hangout meeting/discussion
- I accessed a link or notification through the communication Stream
- I posted a link or notification on the communication Stream

For each Google Classroom tool, indicate how valuable it was for supporting your team's inquiry work over the past month (it made it more difficult, it helped a little, it was somewhat helpful, it was vital to our success):

- Email
- Google Docs/Sheets
- Google Drive
- Google Hangout sessions
- Communication Stream

Do you have any other comments you would like to share related to the use and availability of tools within Google Classroom?

Respond to the following statements related to how your team worked together over the past month.

- For each work format, indicate how productive you feel your team was during the past month (not at all, somewhat, productive, very):
  - In-person meeting
  - Video meeting
  - Collaborating online
  - Working individually
- This month my team accomplished (choose one): all of its work goals, most of its work goals, some of its work goals, few of its work goals
- Because (choose all that apply): we collaborated and everyone completed their assigned responsibilities, one or two members completed all or most of the work, our work plan was not realistic, we could not come to consensus on critical decisions, other:
- This month my team members and I adhered to our team charter, in terms of expectations for communication and collaboration online between meetings: strongly disagree, disagree, agree, strongly agree
- This month my team members and I adhered to our team charter, in terms of expectations for communication and collaboration at both our video and in-person meetings: strongly disagree, disagree, agree, strongly agree

Do you have any other comments related to how your team worked together over the past month?

Final Thoughts:

Over the next month, I hope my team continues to:

One change I would like to see in our inquiry work is:

Survey will be formatted and administered through Qualtrics.

Appendix K

Stakeholder Analysis

	Role in Organization	Stake or interest in: Program	Stake or interest in: Evaluation
Director of Curriculum and Instruction	Oversees curriculum and instruction for the district for all levels and all subject areas. Oversees the district's mathematics leadership team.	Interested in new approach to PD to promote collective responsibility for supporting student math achievement	Utilize results to shift district wide PD approach and potentially scale to other levels and subject areas
Supervisor of Math Teaching and Learning	Oversees mathematics curriculum and instruction for the district for all levels. Leads the district's mathematics leadership team.	Goal for math coaches is to develop sense of collective responsibility for student success across the district	Utilize results to potentially scale model to MS & HS math coaches and to use with classroom teachers
Instructional Specialist	Works out of the Office of Transformation and Innovation. Tasked with increasing educators' use of Google tools for mathematics teaching and learning. Serves as a member of the mathematics leadership team.	Interested in new approach to PD to promote collective responsibility & collaborative efforts for supporting student math achievement	Utilize results to support development of district wide PD shift and potentially scale intervention approach to other levels and subject areas
Elementary MISSLs (n=2)	Support and coordinate the work of the elementary mathematics coaches, including monthly meetings and on-site support. Oversee PD for elementary coaches and teachers.	Goal is for math coaches to develop sense of collective responsibility for student success across the district, as opposed to within individual schools	Utilize results to adapt for future use with coaches & potentially expand for use with classroom teachers
Elementary Mathematics Coaches (n=21)	Support mathematics teaching and learning at their school through instructional coaching and at weekly grade level meetings. Serve as a member of their school's leadership team.	Want more opportunities to collaborate with peers at other schools, easier access to data & resources, & more sustainable support	Utilize results to adapt for future use & potentially expand for coaching work with classroom teachers
Elementary School Principals (n=22)	Lead teaching and learning at their schools. Are linked to district mathematics initiatives, curriculum, and resources through their mathematics coaches & MISSL.	Feel that policies, time, and materials are impeding teachers' mathematics knowledge for teaching development	Utilize results to adjust current PD policies/systems to provide more learning opportunities for teachers
Elementary Classroom Teachers	Lead mathematics instruction and promote student mathematics achievement within their classrooms. Are linked to district initiatives, curriculum, and resources through their mathematics coach.	Want more opportunities to collaborate with peers at other schools, easier access to data & resources, & more sustainable support	Utilize results to develop system for inter-school collaboration
Students		None	Success will improve mathematics instruction and better support their math achievement.

Appendix L

Qualitative Coding Rubric for Examining Critical Colleagueship

	Beginning	Intermediate	High Functioning
Collaborative Interactions	Discussions dominated by 1-2 participants	Discussions involve some members but not distributed among the group	Discussion involves most participants
	Conversation initiated not taken up by the group.	Conversation initiated and taken up by only 1-2 group members.	Conversation initiated and taken up by most members of the group.
	Participant talk is one-sided and egocentric.	Participants begin to listen to each other and validate ideas; some support of each other and some one-sided talk.	Participants listen to each other and pursue each other's ideas; try to understand other's ideas and experiences; offer support to others.
	Participant talk is not connected. Participants shift focus.	Participants begin to have collaborative conversations but still redirect to own interests	Participants raise issues and pursue one another's issues and ideas
Participation and Discourse Norms	Only one perspective represented	Different ideas and perspectives are raised but not always discussed	Different ideas and perspectives are raised and consistently discussed
	Little or no references are made to shared referents or specific school/classroom incidents to build discussion	Some evidence from shared referents or specific school/classroom incidents is used to build discussion	Consistently use evidence from shared referents or specific school/classroom incidents to build discussion
	Little elaboration, probing, or pressing of ideas	Some elaboration, probing, and pressing of ideas	Elaborating, probing, and pressing on one another's ideas frequently occur
Focus of Activity and Discussion	Topics of discussion are peripheral to progress on team's goal, is general in nature and may address a variety of topics peripheral to mathematics teaching and learning.	Discussions focus on progress made on team's goal but are not necessarily connected to mathematics teaching and learning in district schools	Analysis of progress on team's goal is directly connected to mathematics teaching and learning in district schools
	Participants' talk is primarily sharing general experiences and not grounded in shared referents or specific school incidents	Ideas developed with both general experiences and shared referents or specific school incidents	Discussions are grounded in specific mathematics learning and teaching through shared referents or specific classroom incidents

Adapted from van Es' (2012) framework for development of teacher learning community in a video club (Table 4, p. 186).

Appendix M

Collective Mathematics Efficacy for Teaching

Directions: Please indicate your opinion about each of the statements below. Your answers are confidential.	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
Teachers in this district have what it takes to get the children to learn math.	1	2	3	4	5	6	7
Teachers in this district are able to get through to difficult students in math.	1	2	3	4	5	6	7
If a child doesn't learn something in math the first time, teachers will try another way.	1	2	3	4	5	6	7
Teachers here are confident they will be able to motivate their students in math.	1	2	3	4	5	6	7
Teachers in this district really believe every child can learn math.	1	2	3	4	5	6	7
If a child doesn't want to learn teachers give up.	1	2	3	4	5	6	7
Teachers here need more training to know how to deal with these students in math.	1	2	3	4	5	6	7
Teachers in this district think there are some students that no one can reach in math.	1	2	3	4	5	6	7
Teachers here don't have the skills needed to produce meaningful student learning in math.	1	2	3	4	5	6	7
Teachers here fail to reach some students because of poor math teaching methods.	1	2	3	4	5	6	7
These students come to school ready to learn math.	1	2	3	4	5	6	7
Home life factors prevent students from learning math.	1	2	3	4	5	6	7
The lack of instructional materials and supplies makes teaching math very difficult.	1	2	3	4	5	6	7
Students here just aren't motivated to learn math.	1	2	3	4	5	6	7
The quality of school facilitates here really facilitates the math teaching and learning process.	1	2	3	4	5	6	7
The opportunities in this community help ensure that these students will learn math.	1	2	3	4	5	6	7
Teachers here are well prepared to teach the math content they are assigned to teach.	1	2	3	4	5	6	7
Teachers in this school are skilled in various methods of teaching math.	1	2	3	4	5	6	7
Learning math is more difficult at this school because students are worried about their safety.	1	2	3	4	5	6	7
Community factors make learning math difficult for students here.	1	2	3	4	5	6	7
Teachers in this district do not have the skills to deal with student disciplinary problems during math.	1	2	3	4	5	6	7

Adapted from Goddard et al. (2000) to be specific to mathematics teaching.

Appendix N

Internal Social Capital Scale

Directions: Please indicate your opinion about each of the statements below. Your answers are confidential.	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
Teachers engage in open and honest communication with each other.	1	2	3	4	5	6	7
Teachers in this district have no hidden agendas or issues.	1	2	3	4	5	6	7
Teachers share and accept constructive criticism without making it personal.	1	2	3	4	5	6	7
Teachers discuss personal issues if they affect job performance.	1	2	3	4	5	6	7
Teachers willingly share information with one another.	1	2	3	4	5	6	7
Teachers keep each other informed at all times.	1	2	3	4	5	6	7
I can rely on the teachers I work with in this district.	1	2	3	4	5	6	7
Teachers in this district are usually considerate of one another's feelings.	1	2	3	4	5	6	7
Teachers have confidence in one another in this district.	1	2	3	4	5	6	7
Teachers in this district show a great deal of integrity.	1	2	3	4	5	6	7
There is no "team spirit" among teachers in this district.	1	2	3	4	5	6	7
Overall, teachers in this district are trustworthy.	1	2	3	4	5	6	7
Teachers share the same ambitions and vision for the district.	1	2	3	4	5	6	7
Teachers enthusiastically pursue collective goals and mission.	1	2	3	4	5	6	7
There is a commonality of purpose among teachers in this district.	1	2	3	4	5	6	7
Teachers in this district are committed to the goals of the district.	1	2	3	4	5	6	7
Teachers view themselves as partners in charting the district's direction.	1	2	3	4	5	6	7
Everyone is in total agreement on our district's vision.	1	2	3	4	5	6	7

Adapted from Leana & Pil's (2006) Internal Social Capital Scale (p. 364).

Appendix O

Sample Protocols for Establishing Goals and Action Plans

Consulting on a Problem of Practice

A Collaborative Inquiry Protocol[1]

Purpose: This consultation protocol is designed to help a participant work on a problem of practice they are in the midst of and have not yet resolved.

Set-Up (2 minutes)

- Select a time-keeper
- Select a note-taker
- Time-keeper reviews the process

Presenter Overview (7 minutes)

- Share a problem of practice
- *Provide as much background context as is necessary for the group to understand your problem, include solutions you have already considered and rejected or tried*
- Close by clearly stating the problem or by posing a question to the group

Group Questions to Presenter (7 minutes)

- Group members ask clarifying questions
- *This is not a time to give advice or get into the discussion*
- Sample Questions:
    - What makes you think this is a problem? What evidence do you have that indicate this is a problem? Have you been here before? If so, what did you do?
    - How does this problem fit within your theory of action?
    - Where are you with this problem? Are you stuck on anything in particular? If so, what about the problem is “sticky”?
    - What have you done to work on the problem? What have you NOT done?
    - Who will act on this problem?
- As a final step, the note-taker restates the problem or question to the presenter to confirm that the group works on the right problem

Group Collaborative Inquiry (7 minutes)

- *Presenter is silent and resists the urge to defend her/himself or correct any of the group's data or interpretations—remember, the group cannot possibly get it all right, but they might offer new ways of looking at the problem or thinking about solutions*
- Group explores the presenter's interpretation of what is happening in the problem and offers as many different interpretations of what is happening as they can imagine
- Sample Questions:
  - What are different ways to think about the nature of the problem? How can the problem be re-defined?
  - How can we use the presenter's theory of action to get ideas for solutions? What does the presenter value and how can that inform our ideas for solutions? How might the presenter build on work already underway to solve this problem?
  - What assumptions might the presenter hold? How might the presenter test those assumptions? If the assumptions are wrong, what solutions might that open up?

Where Might the Presenter Go from Here? (7 minutes)

- Group provides ideas for the presenter on next steps; ideas should relate directly to insights from the inquiry process
- *Presenter remains silent*
- Group discusses additional evidence the presenter might gather about the problem
- If this is an implementation problem, group thinks about how the presenter can use implementation teams as part of the solution
- Group discusses how the presenter might know if the solutions are working

Presenter Response (3 minutes)

- Presenter reflects on insights gained during the consultation
- *Presenter resists the urge to correct and defend—this is not a time to explain oneself or be defensive, but rather to reflect on the ideas that were generated*
- Sample questions (for the presenter)
  - What were noteworthy comments, insights, or questions?
  - What ideas would you consider trying out?
  - In what ways might you refine your practice as a result of this experience?

Group Debrief (2 minutes)

- Group discusses how the consultation went
- Sample questions
  - What ideas or insights did the *consulting group* garner during the consultation?
  - What portions of the protocol did we struggle with? What might we do differently or better next time?
  - What questions do we have for the planners about the process?

From West Wind Education Policy Inc.

Five Whys Tool for Root Cause Analysis

QAPI

Overview: Root cause analysis is a structured team process that assists in identifying underlying factors or causes of an event, such as an adverse event or near –miss. Understanding the contributing factors or causes of a system failure can help develop actions that sustain corrections.

The Five Whys is a simple problem-solving technique that helps to get to the root of a problem quickly. The Five Whys strategy involves looking at any problem and drilling down by asking: "Why?" or "What caused this problem?" While you want clear and concise answers, you want to avoid answers that are too simple and overlook important details. Typically, the answer to the first "why" should prompt another "why" and the answer to the second "why" will prompt another and so on; hence the name Five Whys. This technique can help you to quickly determine the root cause of a problem. It's simple, and easy to learn and apply.

Directions: The team conducting this root cause analysis does the following:

- Develops the problem statement. (See Step 1 of Guidance for RCA for additional information on problem statements.) Be clear and specific.
- The team facilitator asks why the problem happened and records the team response. To determine if the response is the root cause of the problem, the facilitator asks the team to consider "If the most recent response were corrected, is it likely the problem would recur?" If the answer is yes, it is likely this is a contributing factor, not a root cause.
- If the answer provided is a contributing factor to the problem, the team keeps asking "Why?" until there is agreement from the team that the root cause has been identified.
- It often takes three to five whys, but it can take more than five! So keep going until the team agrees the root cause has been identified.

Tips:

- Include people with personal knowledge of the processes and systems involved in the problem being discussed.
- Note that the Five Whys technique may not always help you to identify the root cause. Another technique you might consider is the fishbone diagram. The fishbone diagram forces you to think broadly across various categories that could be causing or contributing to the problem (See How to Use the Fishbone Tool for Root Cause Analysis tool).

Problem statement	One sentence description of event or problem
Why? ⇨	
Why? ⇨	
Why? ⇨	
Why? ⇨	
Why? ⇨	
Root Cause(s)	1. 2. 3. To validate root causes, ask the following: If you removed this root cause, would this event or problem have been prevented?

Appendix P

Sample Norms, Roles, and Responsibilities Templates

RACI Chart (Roles and Responsibilities Matrix)

For instructions / training material visit http://www.racichart.org

Process Name / Description:	*Plant maintenance project: Repair and resurface plant parking lot during plant shutdown in July*
Created On:	*1-Jan-16* Revision: *3/12/2016*
Created by:	*Kelly Bradley (facilities mgr), Mike Cole (plant manager), Joe Pallino (HR), Brian Sullivan (security), Billy Ownens (project manager)*

	Facilities	Plant Mgr	HR	Security	Project Mgr
Identify a minimum of three asphalt contractors from Angie's List	C	-	-	-	R
Arrange for contractor visits and quotes	I	-	-	-	R
Review quotes and references, make contractor selection	A	I	I	-	R
Review and finalize contract, lock in plant shutdown week	I	I	-	-	R
Communicate project to shutdown maintenance crew, make sure all vehicles are removed from the lot	I	I	R	I	I
Provide security gate access codes for asphalt crew by June 15	I	-	A	R	I
Oversee the project during the plant shutdown week, ensure it is completed on time	A	I	I	-	R

R = Responsible, A = Accountable, C = Consulted, I = Informed

Team roles

Purpose: To develop understanding of the roles and responsibilities of roles that contribute to a team's success

Time: 15 minutes

Materials: Handout 3.3

Steps:

1. Divide into teams of six.
2. Seek a volunteer to serve as facilitator.
3. Assign one role to each team member except the facilitator.
4. Ask each person to read and report on his or her role. The report should include a description of the role, its responsibilities, how the role contributes to the team's success, and current practices related to the roles in participants' schools or districts.
5. Have one person select a role from the list, read the description, and share it with the entire team. Be sure to share not only what a person in this role does, but also why this role helps a team be effective and efficient.

Timekeeper

The timekeeper helps the team stay aware of how it is using time, how much time is assigned to each task, and how much time the team is using to accomplish a specific task. The timekeeper gives advance notice when a time limit is near and helps the team renegotiate time if the task is incomplete and needs further attention. If members agree to give a task more time, the timekeeper helps them adjust time to accomplish the balance of the team's agenda.

Resource manager

The resource manager helps the team have whatever materials, supplies, or other resources it might need to accomplish its goals. The resource manager makes sure the team has these items close by so members don't waste time collecting or finding them during the meeting.

For example, the resource manager might make sure the meeting room has enough outlets for everyone to plug in a computer if needed or that copies are available of the student texts or curriculum the team plans to use. The resource manager might also bring other texts, journals, books, and so on that are related to the focus on the learning. The resource manager also coordinates with all team members to bring resources to the meeting so everything they need is easily accessible.

Recorder

The recorder works with team members to capture big ideas, next actions, topics discussed, information to share outside the team, and so on. The recorder completes the summary log about the meeting and shares it with the principal or posts it on the team's community site. The recorder captures who is responsible for certain tasks prior to the next meeting, the recommended focus for the next meeting, and the resources needed so everyone has a record to review. The recorder works with the summarizer to capture a brief statement of summary about the meeting. Teams sometimes use forms to record their meeting notes.

Process observer

The process observer provides feedback to team members individually and collectively on the team's operations, particularly on how well the team adhered to its agreements and where it veered from them. When teams are new, the process observer might note only strengths. As teams mature, the process observer might note strengths and areas for improvement. The process observer also might engage members in a discussion of their individual and collective behaviors rather than being the person to provide the feedback.

Summarizer

The summarizer helps team members transition from one part of the agenda to the next by summarizing what just occurred. This summary is useful for the recorder and builds in natural transitions within the team's work. Summarizers capture the big ideas, check with the recorder to make sure the ideas are recorded, and help team members stay focused on their work and learning. When a summarizer is not designated within a team, the recorder can serve as the summarizer or the role can rotate among members within a single meeting.

From Learning Forward's Facilitating Learning Teams Handbook

Chat Protocol

- Allow each learner to complete his/her thought before responding – this means do not interrupt or intrude with your thought while another is speaking.
- Be patient – not everyone has advanced keyboard skills.
- Avoid having side conversations; it's rude not to pay attention.
- Signal when you've finished a statement [some use a happy face to signal they have completed their input J].
- Signal when you don't understand something; use a question mark to get the facilitator's attention.
- Signal your "reactions" by using an exclamation mark (!) for surprise, a sad face for disagreement L, or some combination of symbols.
- Do not shout [CAPITALS MEAN THAT YOU ARE SHOUTING].
- Do not leave your computer during a scheduled session; it is impossible to get your attention if you leave the room.
- Officially sign on and off so that everyone knows when you are present.
- Keep statements brief and to the point; the chat box has a limit of 256 characters per statement; you can keep talking, but in spurts.
- Prepare notes and key ideas ahead of time so that you can engage in the discussion without trying to figure out how to word your statements. (CPLI, 2000, p. 45)

Online Discussion Norms (Anderson, 2008, p. 449)

Effective Collaboration Norms and Guidelines

In order to cultivate a climate where everyone is focused on ongoing, positive growth and improving student achievement, use the Seven Norms of Collaboration.

Seven Norms of Collaboration

1. Promoting a Spirit of Inquiry and Balancing Advocacy
Exploring perceptions, assumptions, beliefs, and interpretations promotes the development of understanding. Inquiring into the ideas of others before advocating for one's own ideas is important to productive dialogue and discussion. Advocacy after thoughtful inquiry moves us towards decision-making. Groups take care to balance advocacy with inquiry, so as not to rush to decision-making nor leave issues without closure.

2. Pausing
Pausing before responding or asking a question allows time for thinking and enhances dialogue, discussion, and decision-making.

3. Paraphrasing
Paraphrasing is a powerful way to indicate that you are listening to others and are trying to understand them. Maintain the intention and accuracy of what the speaker said as you recast their contribution in your own words or with an example. Using a paraphrase starter that is comfortable for you – "So…" or "As you are saying…" or "You're thinking…" – and following the starter with an efficient paraphrase assists members of the group in hearing and understanding one another as they converse and make decisions.

4. Probing
Using gentle open-ended probes or inquiries – "Please say more about…" or "I'm interested in…" or "I'd like to hear more about…" or "Then you are saying…" – increases the clarity and precision of the group's thinking.

5. Putting Ideas on the Table
Ideas are the heart of meaningful dialogue and discussion. Label the intention of your comments. For example: "Here is one idea…" or "One thought I have is…" or "Here is a possible approach…" or "Another consideration might be…."

6. Paying Attention to Self and Others
Meaningful dialogue and discussion are facilitated when each group member is conscious of self and of others, is aware of what (s)he is saying, and how it is said as well as how others are responding. This includes paying attention to learning styles when planning, facilitating, and participating in group meetings and conversations.

7. Presuming Positive Intentions
Assuming that others' intentions are positive promotes and facilitates meaningful dialogue and discussion, and prevents unintentional put-downs. Using positive intentions in speech is one manifestation of this norm.

From Expeditionary Learning

Forming Ground Rules

Developed by Marylyn Wentworth.

Ground Rules, or Norms, are important for a group that intends to work together on difficult issues, or who will be working together over time. They may be added to, or condensed, as the group progresses. Starting with basic Ground Rules builds trust, clarifies group expectations of one another, and establishes points of "reflection" to see how the group is doing regarding process.

Time
Approximately 30 minutes

1. Ask everyone to **write down what each person needs in order to work productively in a group**, giving an example of one thing the facilitator needs, i.e. "to have all voices heard," or "to start and end our meetings when we say we will." (This is to help people focus on process rather than product)

2. **Each participant names <u>one</u> thing from his/her written list**, going around in a circle, with no repeats, and as many circuits as necessary to have all the ground rules listed.

3. **Ask for any clarifications** needed. One person may not understand what another person has listed, or may interpret the language differently.

4. **If the list is VERY long – more than 10 Ground Rules — ask the group if some of them can be combined to make the list more manageable**. Sometimes the subtle differences are important to people, so it is more important that everyone feel their needs have been honored than it is to have a short list.

5. **Ask if everyone can abide by the listed Ground Rules**. If anyone dislikes or doesn't want to comply with one of them, that Ground Rule should be discussed and a decision should be made to keep it on the list with a notation of objection, to remove it, or to try it for a specified amount of time and check it again.

6. **Ask if any one of the Ground Rules might be hard for the group to follow**. If there is one or more, those Ground Rules should be highlighted and given attention. With time it will become clear if it should be dropped, or needs significant work. Sometimes what might appear to be a difficult rule turns out not to be hard at all. "Everyone has a turn to speak," is sometimes debated for example, with the argument that not everyone likes to talk every time an issue is raised, and others think aloud and only process well if they have the space to do that. Frequently, a system of checking in with everyone, without requiring everyone to speak, becomes a more effective ground rule.

7. **While work is in progress, refer to the Ground Rules whenever they would help group process**. If one person is dominating, for example, it is easier to refer to a Ground Rule that says, "take care with how often and how long you speak," than to ask someone directly to stop dominating the group.

8. **Check in on the Ground Rules when reflection is done on the group work.** Note any that were not followed particularly well for attention in the next work session. Being sure they are followed, refining them, and adding or subtracting Ground Rules is important, as it makes for smoother work and more trust within the group.

From National School Reform Faculty

Appendix Q

Monthly Inquiry Team Work Agendas

August 2017	All teams will:
	- Participate in an ice breaker activity that requires discourse around differing solutions.
	  - Review roles & norms established at June meeting. Adjust as necessary for new team members.
	- Create a team charter using the CATME as a template (modified for our work; need to include expectations for asynchronous work)
	  o determine collaboration norms, roles & responsibilities for:
	    ▪ synchronous meetings
	    ▪ asynchronous communications
		Each team will:
		- Examine Instructional Rounds data/recommendations (access in Google Drive):
		  o Share out by school
		  o Determine commonalities
		  o Brainstorm pluses & minuses of focusing on each one (team member characteristics, existing initiatives/overlap, availability of resources, etc.)
		  o Come to consensus on focus for fall inquiry work using the "5 Whys" protocol
		- Complete School Action Planning template
		  o Use SMART goal template to restate long term goal
		  o Determine success criteria/measurement for long term goal
		  o Specify action steps by completing the small-win strategies; you should be able to accomplish a "small-win" each month (Oct., Nov, & Dec)
		  o Determine success criteria or deliverable for each month aligned to each "small-win"
		- Schedule synchronous meeting for Sept. (3 hrs)
			Face-to-face meeting, half-day as part of summer MSP professional development
			
			All teams present, but will meet as individual teams
				Participants will complete pre-assessments for collective MEFT and internal social capital perceptions using a Qualtrics online survey
				
				Critical colleagueship data will be collected from transcripts of team meeting audio recordings and analyzed using van Es rubric

		- Individuals will begin to gather resources for work on SMART goal	Asynchronous work	Researcher will monitor asynchronous communications to collect critical colleagueship data
September 2017	Individuals will provide feedback to partner team regarding CIT action plan & share resources as appropriate	Each individual will: - provide constructive feedback for the CIT Action Plan of their partner team using the comment tool within Google Drive (due by partner team's synch meeting): questions about focus or timeline & ideas for resources or action steps - Begin to gather data & resources specific to team goal to share at synchronous meeting (due by synch meeting) - Communicate with team members as needed	Asynchronous work	Researcher will monitor asynchronous communications to collect critical colleagueship data
	Each team will: - Provide individuals with an opportunity to share personal or professional "news" - Share collaboration issues from asynchronous work & problem solve/adjust expectations as needed - Review synchronous collaboration norms & logistics	Each team will: - Review feedback from partner team - Share gathered data and resources specific to their chosen goal - use these to create a specific action plan for "small-win 1" - distribute workload by assigning specific tasks to individuals due at f2f meeting & next synch meeting	Online synchronous meeting	Researcher will monitor recordings/transcripts from synchronous meetings to collect critical colleagueship data
	Teams will: - participate in a team building activity - share progress & struggles with partner team & provide constructive feedback to each other Each team will: - share out collaboration issues from asynchronous and/or synchronous work - adjust norms & role expectations as needed	Each team will: - share data & resources gathered - discuss progress made on "small-win 1" - determine work still need to be done to complete "small-win 1" & distribute remaining workload with deliverables - draft a plan for beginning work on "small-win 2" & update CIT Action Plan - share updated CIT Action Plan with partner team (Google Drive) - Schedule synch meeting for Oct. (3 hrs)	Face-to-face meeting	Participants will provide feedback around system & team functionality using online Qualtrics survey Researcher will monitor recordings/transcripts from f2f meetings to collect critical colleagueship data

	Individuals will provide feedback to partner team regarding updated CIT Action Plan	Each individual will: - provide constructive feedback for the updated CIT Action Plan of their partner team using the comment tool within Google Drive (due by partner team's synch meeting): questions about focus or timeline & ideas for resources or action steps for "small-wins" #1 & #2 - complete assigned work to complete "small-win 1" & prepare to share at f2f meeting - begin to gather data & resources for "small-win 2" (due by synch meeting) - communicate with team members as needed	Asynchronous work	Researcher will monitor asynchronous communications to collect critical colleagueship data
	Each team will: - Provide individuals with an opportunity to share personal or professional "news" - Share collaboration issues from asynchronous work & problem solve/adjust expectations as needed - Review synchronous collaboration norms & logistics	Each team will: - Review feedback from partner team - Share gathered work done to date on "small-win 1"; Draft success report to share at f2f meeting - Determine if success criteria have been met for "small-win 1"; if not determine work still to be done - Use gathered resources & feedback to update/revise action plan for "small-win 2" - Distribute workload for individual work due at f2f meeting & next synch meeting	Synchronous meeting	Researcher will monitor recordings/transcripts from synchronous meetings to collect critical colleagueship data
October 2017	Teams will: - participate in a team building activity - share "small-win 1" success report with all teams - discuss progress & struggles with partner team & provide constructive feedback to each other Each team will: - share out collaboration issues from asynchronous and/or synchronous work - adjust norms & role expectations as needed	Each team will: - share data & resources gathered - discuss progress made on "small-wins" #1 & 2 - determine work still need to be done to complete "small-win 2" & distribute remaining workload with deliverables - draft a plan for beginning work on "small-win 3" & update CIT Action Plan - share updated CIT Action Plan with partner team (Google Drive) Schedule synch meeting for Nov. (3 hrs)	Face-to-face meeting	Participants will provide feedback around system & team functionality using online Qualtrics survey Researcher will monitor recordings/transcripts from f2f meetings to collect critical colleagueship data
	Individuals will provide feedback to partner team regarding updated CIT Action Plan	Each individual will: - provide constructive feedback for the updated CIT Action Plan of their partner team using the comment tool within Google Drive (due by partner team's synch meeting): questions about focus or timeline & ideas for resources or action steps for "small-wins" #2 & 3 - complete assigned work to complete "small-win 2" & prepare to share at f2f meeting - begin to gather data & resources for "small-win 3" (due by synch meeting) - communicate with team members as needed	Asynchronous work	Researcher will monitor asynchronous communications to collect critical colleagueship data
	Each team will: - Provide individuals with an opportunity to share personal or professional "news" - Share collaboration issues from asynchronous work & problem solve/adjust expectations as needed - Review synchronous collaboration norms & logistics	Each team will: - Review feedback from partner team - Share gathered work done to date on "small-win 2"; Draft success report to share at f2f meeting - Determine if success criteria have been met for "small-win 2"; if not determine work still to be done - Use gathered resources & feedback to update/revise action plan for "small-win 3" - Distribute workload for individual work due at f2f meeting & next synch meeting	Synchronous meeting	Researcher will monitor recordings/transcripts from synchronous meetings to collect critical colleagueship data
November 2017	Teams will: - participate in a team building activity - share "small-win 2" success report with all teams - discuss progress & struggles with partner team & provide constructive feedback to each other Each team will: - share out collaboration issues from asynchronous and/or synchronous work - adjust norms & role expectations as needed	Each team will: - share data & resources gathered - discuss progress made on "small-wins" #2 & 3 - determine work still need to be done to complete "small-win 3" & distribute remaining workload with deliverables - update CIT Action Plan to represent final action plan for completing work by January - share updated CIT Action Plan with partner team (Google Drive) - Schedule synch meeting for Dec. (3 hrs)	Face-to-face meeting	Participants will provide feedback around system & team functionality using online Qualtrics survey Researcher will monitor recordings/transcripts from f2f meetings to collect critical colleagueship data

	Individuals will provide feedback to partner team regarding updated CIT Action Plan	Each individual will: - provide constructive feedback for the updated CIT Action Plan of their partner team using the comment tool within Google Drive (due by partner team's synch meeting): questions about focus or timeline & ideas for resources or action steps for "small-win 3" - complete assigned work to complete "small-win 3" & prepare to share at f2f meeting - communicate with team members as needed	Asynchronous work	Researcher will monitor asynchronous communications to collect critical colleagueship data
	Each team will: - Provide individuals with an opportunity to share personal or professional "news" - Share collaboration issues from asynchronous work & problem solve/adjust expectations as needed - Review synchronous collaboration norms & logistics	Each team will: - Review feedback from partner team - Share gathered work done to date on "small-win 3"; Draft success report to share at f2f meeting - Determine if success criteria have been met for "small-win 3"; if not determine work still to be done - Use gathered resources & feedback to update/revise action plan for completing CIT Action Plan - Distribute workload for individual work due at f2f meeting & next synch meeting	Synchronous meeting	Researcher will monitor recordings/transcripts from synchronous meetings to collect critical colleagueship data
December 2017	Teams will: - participate in a team building activity - share "small-win 3" success report with all teams - discuss progress & struggles with partner team & provide constructive feedback to each other Each team will: - share out collaboration issues from asynchronous and/or synchronous work - adjust norms & role expectations as needed	Each team will: - share data & resources gathered - discuss progress made on "small-wins" #3 - determine work still need to be done to complete SAP & distribute remaining workload with deliverables - finalize plans for completing CIT Action Plan work - share updated CIT Action Plan with partner team (Google Drive) Schedule synch meeting for Jan. (3 hrs)	Face-to-face meeting	Participants will provide feedback around system & team functionality using online Qualtrics survey Researcher will monitor recordings/transcripts from f2f meetings to collect critical colleagueship data
	Individuals will provide feedback to partner team regarding updated CIT Action Plan	Each individual will: - provide constructive feedback for the updated CIT Action Plan of their partner team using the comment tool within Google Drive (due by partner team's synch meeting): questions about focus or timeline & ideas for resources or action steps for completing CIT Action Plan - complete assigned work to complete CIT Action Plan work & prepare to share at f2f meeting - communicate with team members as needed	Asynchronous work	Researcher will monitor asynchronous communications to collect critical colleagueship data
	Each team will: - Provide individuals with an opportunity to share personal or professional "news" - Share collaboration issues from asynchronous work & problem solve/adjust expectations as needed - Review synchronous collaboration norms & logistics	Each team will: - Review feedback from partner team - Share CIT Action Plan work completed to date - Determine if success criteria have been met for all "small-wins"; if not determine work still to be done - Update/revise action plan for completing CIT Action Plan - Distribute workload for individual work due at f2f meeting & next synch meeting	Synchronous	Researcher will monitor recordings/transcripts from synchronous meetings to collect critical colleagueship data
January 2018	Teams will: - participate in a team building activity - discuss progress & struggles with partner team & provide constructive feedback to each other Each team will: - share out collaboration issues from asynchronous and/or synchronous work - adjust norms & role expectations as needed	Each team will: - share work completed to date - Determine if success criteria have been met for all "small-wins"; if not determine work still to be done - Draft report of CIT Action Plan work to be presented at next f2f meeting - Distribute workload for completing any outstanding work & creating report/presentation for Feb. f2f meeting Schedule synch meeting for Feb. (3 hrs)	Face-to-face meeting	Participants will provide feedback around system & team functionality using online Qualtrics survey Researcher will monitor recordings/transcripts from f2f meetings to collect critical colleagueship data
	Individuals will continue to work as a team to complete CIT Action Plan work	Each individual will: - complete assigned work to complete CIT Action Plan work & including preparation of final report/presentation - communicate with team members as needed	Asynchronous work	Researcher will monitor asynchronous communications to collect critical colleagueship data
	Each team will: - Provide individuals with an opportunity to share personal or professional "news" - Share collaboration issues from asynchronous work & problem solve/adjust expectations as needed - Review synchronous collaboration norms & logistics	Each team will: - Share CIT Action Plan work completed to date - Determine if success criteria have been met for all "small-wins"; if not determine work still to be done - Share report/presentation work done to date; determine work still to be done - Distribute workload for individual work to ensure project completion	Synchronous	Researcher will monitor recordings/transcripts from synchronous meetings to collect critical colleagueship data
February 2018	Teams will: - participate in a celebration of work completed - share their final reports/presentations - discuss pros & cons of blended inquiry team process	Each team will: - share their reports/presentations with each other - establish plans for spring work	Face-to-face meeting	Participants will provide feedback around system & team functionality using online Qualtrics survey Researcher will monitor recordings/transcripts from f2f meetings to collect critical colleagueship data Participants will complete post-assessments for MEFT and internal social capital perceptions using an online Qualtrics survey

Appendix R

Participant Recruitment Script

Hello, my name is Sara Donaldson. I am a doctoral student at the Johns Hopkins University in the School of Education. I am conducting research on strategies for providing sustainable professional support for elementary math educators in urban school districts, and I am inviting you to participate because of your role in supporting math education in your district.

Participation in this research includes both participating in a collaborative inquiry process over the next six months as part of your daily work and providing data related to that work.
Participating in the collaborative inquiry process will include work at your regularly scheduled monthly coaches' meetings, a monthly online meeting with your cohort using Google Hangouts, and ongoing inquiry work within your Google Classroom space. All of this work will occur within your regular work hours and within your current contractual obligations. If you agree to participate, you will be asked to grant me permission to collect audio recordings of your in- person and online meetings and to access email and other online interactions you have with other study participants. This data will all be kept confidential.

In addition to participating in the collaborative inquiry, I will ask you to complete an online survey about your beliefs about math teaching and learning in your district both today, before the study begins and again in February when the study ends. The survey should take not more than 20 minutes to complete. And finally, you will be asked to provide feedback about the collaborative inquiry process each month at your coaches' meetings to provide data to help improve the process as the study progresses. This monthly online feedback survey should take no more than 10 minutes to complete. These survey data will be kept confidential.

You are not obligated to participate in this study and your decision will in no way impact your job. You may also choose to terminate your participation at any point during the study. I will ensure that district administrators are not aware of your decision. If you have any questions about the study, either today or in the future, you can ask me either in person, by email or by phone.

I will be passing around consent letters. If you are willing to participate, please sign the letter and then place it in the envelope on the front table. If you do not wish to participate, you can simply return your blank letter to the envelope.

Thank you.

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Curriculum Vitae

EDUCATION

Johns Hopkins University, Baltimore, MD
Doctorate of Education (Ed.D.) **2018**
Dissertation: "A Mixed Methods Study of Critical Colleagueship as Sustainable Support for Elementary Mathematics Leaders"
Merit Scholarship (2016-2018)

University of New Hampshire, Durham, NH
M.Ed. in Elementary Education **1993**
Thesis: "Sailing: An Adventure Through Science and Time" (an interdisciplinary curriculum design project)

University of New Hampshire, Durham, NH
BA in Social Work **1992**
Summa Cum Laude

COURSE DEVELOPMENT AND TEACHING EXPERIENCE

Johns Hopkins University, Baltimore, MD
Adjunct Faculty, Online Course Development, School of Education **2018 through present**

- New course development for Mathematics/STEM Instructional Leader (PK-6) program, including: identification of learning objectives, assessments, course outline, and session content and delivery.

Graduate Teaching Assistant, School of Education **2017 through present**

- Provide synchronous and asynchronous e-learning support for doctoral students
- Engage in research investigating strategies and technologies for supporting community building in online learning programs

Roger Williams University, Bristol, RI
Adjunct Faculty and Clinical Educator, Department of Education **2013 through present**

- Supervise and instruct MAT, Secondary Mathematics, and Elementary Education students during practicum and student teaching experiences and seminars
- Develop relationships with school and district personnel to support ongoing university partnerships
- Collaborate with colleagues to develop and revise assignments, rubrics, and professional development opportunities for pre-service teachers
- Develop, redesign, and facilitate courses to support university initiatives
  * Increasing blended/hybrid learning opportunities to promote student access
  * Developing community partnerships to support local communities and deepen student knowledge through real-world learning experiences
- ***Certified for online teaching, January 2015***

K-12 Classroom Teaching Experience **1993 - 2005**
Paul Cuffee Charter School, Providence, RI (Classroom teacher; Science Curriculum Coordinator; Board Member)

Parker-Varney Elementary School, Manchester, NH (Classroom teacher)
* Recipient: *"For Manchester Excellence in Education Award"*
Beech Street Elementary School, Manchester, NH (Title I Mathematics and Literacy Instructor)
Barrington Middle School, Barrington, NH (Classroom teacher)

PROFESSIONAL DEVELOPMENT AND INSTRUCTIONAL COACHING EXPERIENCE

Independent Contractor, Southeastern New England
Educational Consultant **2005 – present**

- Design and facilitate professional development opportunities for K-12 educators in various areas, including mathematics content, instructional pedagogy, behavior management, and co-teaching models for inclusive classrooms
- Mentor and coach regular and special education teachers in classroom settings
- Develop and refine curriculum, alongside district personnel, using needs analyses

Rhode Island Department of Education, Providence, RI
Independent Service Provider **2012 – 2016**

- Developed and facilitated statewide workshops to support implementation of the Common Core State Standards for Mathematics
- Designed online professional development modules for mathematics content using Articulate Software
- Facilitated implementation of state education initiatives in East Bay school districts.

East Bay Educational Collaborative, Warren, RI
Professional Development Specialist, Mathematics **2010 - 2015**

- Supported preK-12 classroom teachers and special educators deepen content knowledge and expand pedagogical skill base to support intervention and instructional differentiation
- Designed and facilitated instructional units, professional modules, and full day workshops to support professional knowledge development and instructional implementation
- Coordinated cross-district initiatives related to standards-based assessments, formative assessment, and effective feedback systems.

Paul Cuffee School, Providence, RI
Curriculum and Professional Development Coordinator **2007 - 2010**

- Collaborated with academic heads to develop and maintain an effective professional learning community through group visioning, action planning, and standards-based curriculum and assessment development
- Coordinated community partnerships
- Created and facilitated a mentoring program for new teachers

PUBLICATIONS

"Critical Colleagueship: Teaming up for Professional Growth"
New England Mathematics Journal **2017**

PRESENTATIONS

"Supporting Academic Literacy for All: Developing Students' Ability to Read, Write, Listen, Speak, and Think Like Mathematicians"
Association of Mathematics Teachers New England Fall Conference **2018**

"Strategies for Building Meaningful Student-faculty Relationships to Increase Online Engagement "
New England Faculty Development Consortium: Spring Conference **2018**

"Connected: Building Community and Engaging in Authentic Learning in Higher Education"
Lilly Conference-Bethesda: Designing Effective Teaching **2018**

"Fraction Operations in the Common Core"
Rhode Island Mathematics Teachers Association's Spring Rhode Show **2013**

"Building Coherence in Fraction Instruction: Grades 3-5"
Rhode Island Department of Education, Professional Development Series **2013**

"Teacher Assistants: Supporting Students in Mathematics"
Northern Rhode Island Collaborative, Teacher Assistant Training Series **2013**

"Moving Mathematical Thinking Forward: Connecting Developmental Numeracy and the Common Core State Standards for Mathematics"
Rhode Island Department of Education, Professional Development Series **2013**