NETWORKED IMPROVEMENT COMMUNITY DEVELOPMENT AND COHERENCE IN AN URBAN PUBLIC SCHOOL SETTING

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Submitted to the faculty of the School of Education
in partial fulfillment of the requirements
for the degree
Doctor of Education
in the Department of Education
in the Department of Educational Leadership and Policy Studies,
Indiana University
July 2023

Accepted by the School of Education Faculty, Indiana University, in partial fulfillment of the requirements for the degree of Doctor of Education.

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Date of Defense: May 10, 2023

This dissertation is dedicated to my family and dearest friends. Without all of you, I would not have achieved my lifelong dream, and I am eternally grateful and blessed because of each of you.

To my parents, who were my most incredible supporters during their lives. They always encouraged me to chase my dreams. To my kids, who have cheered me on and endured the long days with me. To my dearest friends who have provided emotional support and encouragement.

To my IU cohort, you are the best!

Most importantly, to my husband, who has championed me throughout this process and has done so many things behind the scenes so that I could pursue this degree. We've conquered so much in this process, and the best is yet to come!

Acknowledgments

“For I know the plans I have for you,” declares the Lord, “plans to prosper you and not harm you, plans to give you hope and a future.”—Jeremiah 29:11 NIV Bible. First and foremost, thank you to Jesus Christ, my Lord and Savior. In every moment, He has provided me with all my needs, and my prayer is to fulfill His purpose in my calling in education.

I have been fortunate to interact with many great teachers throughout my life. I want to formally acknowledge their impact on my life.

Sue Fry, you are a model of teaching and love. I am grateful to you for your support in my youth, as my teacher, and as my bonus mom.

Dr. Raimondi, that single phone call changed my entire future. I am so grateful for your belief in me as an educational leader.

Dee, I am so grateful for all you did to support me in this endeavor. Most wouldn’t understand why you did so much, but you believed this was God’s plan. Thank you for your friendship and your prayers throughout this journey. You are an angel.

To the past and present faculty of the Educational Leadership doctoral program who shared their experiences and knowledge, thank you for your dedication to supporting leaders and future leaders. I appreciate the support you provided during this program.

Finally, I want to acknowledge and say thank you to the members of my dissertation committee. Your support has blessed me, and I am so grateful to each of you.

Dr. Perrone, I enjoyed our interactions on developing teacher leadership opportunities. Thank you for being on my dissertation committee.

Dr. Rippner, our interactions and my continued learning of education law have influenced my work on this dissertation. Thank you for sharing your expertise and for being on my dissertation committee.

Dr. Lochmiller, you have been a guiding force and inspiration in my work as an instructional leader. I want to express my sincere gratitude for the opportunity to work with you in educational leadership and research. Those experiences continue to impact every aspect of my work as a leader. Your guidance through courses, research, and writing model true excellence in education. Indeed, you are an extraordinary mentor and teacher, and I am so blessed to learn from you. Thank you for all your support and encouragement.

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NETWORKED IMPROVEMENT COMMUNITY DEVELOPMENT AND COHERENCE IN AN URBAN PUBLIC SCHOOL SETTING

Networked improvement communities (NICs) have emerged as a comprehensive reform strategy that can be used to solve complex educational issues and improve student outcomes. NICs focus on equitable improvement that solves persistent issues in education and attends to the context of the challenge (Bryk et al., 2015). The purpose of this study is to understand how the development of a NIC and its emphasis on improvement science tools increase teachers' understanding of problems of practice while also contributing to instructional coherence across their classrooms. The study seeks to understand how this work informs the principal's approach to teaching and learning. Drawing from a qualitative case study conducted in two urban elementary schools, the study included interviews, focus groups, observations, and document retrieval. The findings indicate that teachers in the case study initially struggled to use improvement science tools and inquiry processes, that is, root cause analysis, fishbone diagrams, and plan-do-study-act (PDSA) cycles. Data collection, organization, and use were also challenging but supported teachers in implementing PDSA cycles. Analysis indicates that over time and through collaboration with members of the NIC, the teachers came to understand and more clearly define instructional practices in their classrooms. Principals who participated in the study found it beneficial to use a coaching stance and specific question stems aligned with the inquiry process to support teaching and learning. The study has implications for the research on school improvement and the expanding literature base on networked improvement science.

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Chapter 1.

Introduction

Over the past several decades, various groups have searched for ways to improve educational outcomes for increasingly diverse groups of students. This shift has been inspired, in part, by the accountability era and its incisive focus on student learning outcomes. From the Elementary and Secondary Education Act (ESEA, 1965) to its present-day version, that is, the Every Student Succeeds Act (ESSA), the United States has been on a mission to solve the issues that exist in our educational system ("Every Student Succeeds," 2017). ESEA was initially enacted to provide more equitable outcomes, but the legislation produced only modest results. Thus, a more recent update, No Child Left Behind (2002), required schools to meet goals or face sanctions, unlike its predecessor, ESEA (Goldrick-Rab & Mazzeo, 2005). The latest version, ESSA, provides some flexibility for states and local education agencies but still requires transparency and accountability to ensure students are college and career ready (PL. 114-95 § 114 Stat. 1177 (2015-2016)). Furthermore, ESSA requires schools to find a means of ensuring better student learning ("Every Student Succeeds," 2017).

In light of these policy pressures, public school systems must be prepared to educate all children who enroll within their attendance areas. Students enrolled in urban public schools often vary by socioeconomic status, cultural background, academic needs, and so forth. Thus, public education systems are designed to meet the continually expanding needs of a diverse population (Cannata et al., 2017). One of the main requirements of the law is academic performance–based accountability. Although ESSA has expanded responsibility into other areas (PL. 114-95 § 114 Stat. 1177 (2015–2016)), the public typically focuses on state-mandated academic test scores to

measure academic success, in which these state-mandated accountability assessments focus primarily on reading and mathematics.

ESSA requires states and local education agencies (LEAs) to improve the effectiveness of teachers and principals to improve academic achievement (PL. 114-95 § 114 Stat. 1177 (2015–2016)). Previous research has found that teachers significantly impact student learning (Louis et al., 2010; Nye et al., 2004). Additionally, researchers have elevated the second most important factor in student learning—the impact school leaders have on student achievement through their work with teachers (Louis et al., 2010). Finally, Louis et al. (2010) provide critical insights into the impact of district personnel through the policies they enact and the practices they implement. Thus, the law reflects contemporary educational research on the influences of school personnel on student achievement. Indeed, systems leaders in districts focus on improving instructional coherence as one response to the multifaceted challenges embedded in law and policy (Spillane, 2022). However, the law alone is an insufficient mandate to effect the change it requires.

Teachers' instructional quality matters in all of the courses students take, including mathematics. Several factors impact instructional quality in mathematics. For instance, researchers have ascertained that pedagogical content knowledge (Baumert & Kunter, 2013) and diagnostic skills of mathematics educators as related to planning, monitoring for learning, and assessment (Bruner et al., 2013) have a positive effect on student achievement. For urban public schools, the variance in the instructional quality of mathematics leads to continued challenges in providing equitable, improved outcomes for the various student populations they serve.

Not surprisingly, given the pressure to improve instructional quality and student outcomes, numerous public school reform efforts have been introduced with varying degrees of

success. Several approaches have been used to improve student outcomes in public education, particularly in urban settings. Early on, national policy focused on equity-based reform (Jennings, 2012). This reform has led to add-on services for diverse student groups but has not shown a direct link to improved student outcomes (Jennings, 2012). Another reform effort, the standards-based movement, clarifies what should be taught and when (Jennings, 2012). However, these reforms did not achieve the intended outcomes, even though they were designed to work in tandem with accountability measures to increase student achievement.

Some measures have focused on rewarding effective teachers and penalizing those deemed ineffective. In some states, the legislators introduced value-added measures for teachers. However, yearly value-added measures did not provide accurate information about instructional effectiveness (Jennings, 2012). Additionally, some policymakers have touted the school turnaround model as a means of school improvement, but the model has not produced the expected success (Peck & Reitzug, 2014). Some reform efforts have used a system that included punitive measures as a catalyst for change, but these reforms have not successfully created sustained student success either. Thus, LEAs must seek other ways to improve student achievement.

Schools and school districts often add programs or resources to improve student learning and frequently do so in response to the accountability pressures derived from the policy environment. This can create an issue in school improvement when the programs are disconnected and unsustainable (Newman et al., 2001). Newman et al. (2001) argue that urban districts have struggled because of various demands on public education. These varied demands and expected diverse outcomes create a lack of programmatic coherence across school districts. The authors further argue that education research does not provide the same level of reliable

methods to support student learning, further fragmenting implementation and decreasing coherence. However, Bryk (2010) notes that coherent curricular resources are one of several essential supports in school improvement. Add-on programs and resources alone fall short in improving student achievement. Indeed, how they are integrated into existing district programs and adopted in practice ultimately determines how they impact students.

Professional development is another method used to improve teaching and learning (Desimone et al., 2002). In mathematics, professional development strategies have had mixed results (e.g., see Garet et al., 2011; Roschelle et al., 2010). More recently, the National Council for the Teachers of Mathematics (2014) has called for high-level effective mathematics instruction, a shift from previous basic instruction. One recent three-year elementary mathematics impact study indicates that the researched professional development program had no impact on the instructional practice or student achievement and limited positive effect on teacher content knowledge (Jacob et al., 2017). Jacob et al. (2017) also show that the level of district and principal support changed over time, which may have played some role in the results across the three years of the study. Some districts take a different approach and invest in coaches to improve instruction and pedagogy, but the results are mixed and vary across contexts (Desimone & Pak, 2017; Mangin & Dunsmore, 2015; Saclarides & Lubienski, 2020). In one study, Saclarides and Lubienski (2020) find that the various foci of administrators created a lack of coherence during math coaching cycles. Given the combined expectations for higher accountability, more effective instructional implementation, and increased student outcomes in a diverse landscape, educators need to consider a coordinated improvement method.

Ultimately, the wicked problems (Rittel & Webber, 1973) we seek to solve through policy have no straightforward answers or linear solutions (Gomez et al., 2016). Instead, they

require many experts of varying backgrounds to work together toward a common goal (Gomez et al., 2016). ESSA has returned supervision for school improvement back to the states. This shift in oversight provides states with a ripe opportunity to learn what does and does not work to improve student outcomes in varied contexts (VanGronigen & Meyers, 2019). Different types of networks have emerged in response to the pressures to improve educational outcomes (Glazer & Peurach, 2013; Peurach et al., 2019a; Smith & Wohlstetter, 2001). Indeed, networks have become a more commonly used structure to support educator learning and facilitate sharing of best practices.

Historically, several types of networks have been introduced to improve outcomes or systems. Smith and Wohlstetter (2001) define four specific types of networks that have been implemented. The first type, a *professional network,* refers to an optional network of educators who come together to learn from each other (Smith & Wohlstetter, 2001). A *policy issue network* forms to advance specific issues with policymakers (Smith & Wohlstetter, 2001). A third type uses *external partners*; Smith and Wohlstetter (2001) define this network as one where additional services are provided to students and are used on an individual school basis. Finally, the authors describe an *affiliation network* as a membership-based network where various organizations "work together to solve a problem or issue of mutual concern that is too large for any one organization to handle on its own" (Smith & Wohlstetter, 2001, p. 501). The specific affiliation network researched in the authors' study connected a network of schools and community partners (Smith & Wohlstetter, 2001). More recently, school improvement networks have developed. Glazer and Peurach (2013) define *school improvement networks* as a "quasi-education" system that includes a network provider and supports large-scale improvement efforts (p. 677).

Another collaborative effort with schools, districts, and external partners is research-practice partnerships (RPPs), which are defined as "long-term, mutualistic collaborations between practitioners and researchers that are intentionally organized to investigate problems of practice and solutions for improving district outcomes" (Coburn et al., 2013, p. 2). Additionally, Networked Improvement Communities have been introduced to address systemic problems. For the present study, a *networked improvement community* (NIC) is defined as a specifically focused execution network designed to address systemic problems faced in urban education (Gomez et al., 2016; Harris et al., 2009). Within a NIC, network members work to improve student outcomes within their context. Network members can include teachers, school administrators, district administrators, other personnel within and across districts, personnel in higher education, and members of other nonprofit groups.

NICs have emerged as a comprehensive reform effort to increase student achievement. NICs focus on equitable improvement that solves persistent issues in education and attends to the context of the challenge (Bryk et al., 2015). Some NIC partners are trying to better understand how to scale improvement (Cannata et al., 2017). However, some researchers, such as Fullan (2016), refute the notion of scale and instead emphasize the need for "deep pedagogical change based on the relationships among learners … and solutions that successfully address equity" (p. 540). It is essential to consider the local context while combining the notion of learners at all levels of an enterprise engaged in pedagogical change and deep learning to ensure that typically more successful and traditionally disadvantaged students have improved outcomes. The current study limits the scope of research to one specific area of school reform—the use of a NIC that has been designed to address a problem of practice and improve student outcomes in elementary mathematics.

Motivation for the Study

As an urban school district administrator, I am constantly searching for new ways to support improved student outcomes. My responsibilities include ensuring that elementary math students can advance to secondary mathematics with the concepts, skills, and problem-solving capacities necessary to succeed. To this end, I worked with an emerging NIC that included elementary school teachers focused on improving elementary mathematics outcomes. This work has led to an extensive literature review to find research that could benefit other leaders and me within our district. However, there is little research about teachers' and principals' roles and experiences in NICs that could inform a leader's work in elementary mathematics education. This likely reflects the relatively new status that this intervention has. Thus, current research has a gap in understanding that could be informative for various actors that function in a NIC involving elementary school math teachers. Additionally, I would find research about teachers' and principals' roles and experiences in NICs focused on elementary mathematics helpful as a district administrator.

In the present study, I use the concept of coherence as defined by Honig and Hatch (2004) to situate and inform my interpretation of the data. The authors define coherence as "an ongoing process" rather than "the objective alignment of curriculum, instruction, and assessments by agents either internal or external to schools" (Honig & Hatch, 2004, p. 26). As such, their study conceptualizes coherence as an active process shaped by the work of leaders and teachers in relation to specific problems of practice. Coherence moves beyond finite products or systems to the evolution of both through "productive goal and strategy setting" (Honig & Hatch, 2004, p. 20). The authors have identified specific conditions, capacities, and activities that support both (Honig & Hatch, 2004). One area that could enhance the existing research is to show how a NIC

contributes to improved coherence in relation to adopting a specific instructional reform. Indeed, understanding the conditions, activities, and learning that will enhance coherence could be informative for those working with teachers as members of a NIC.

Purpose of the Research

The purpose of the present study is to understand how the development of a NIC and its related emphasis on root cause analysis and plan-do-study-act (PDSA) cycles increases coherence in instructional practice across classrooms and schools in an urban school setting. Specifically, the current study will examine how teachers engaged in the process share understanding of the problem of practice they are collectively attempting to address. In addition, the study seeks to determine how the shared understanding impacts the principals' approach to teaching and learning.

Three questions guide this study, as follows:

- How do teachers engaged in an emerging NIC use root cause analysis (RCA) to promote a coherent understanding of the problems they are facing in their classrooms, if at all?
- How do repeated testing cycles through a PDSA contribute to the teacher's understanding of the problems they are facing?
- In what ways does the shared understanding of a problem of practice derived through the RCA and PDSA better inform the principal's approach to improving teaching and learning?

Significance

Teachers' perspectives are an essential consideration for administrators and other stakeholders who seek to make a positive impact on school improvement. Research states

significant variability exists in classroom implementation and student outcomes (Russell et al., 2017). However, current research has not focused on improvement science and NIC development that includes the teacher lens. The present study seeks to illuminate that perspective. It is designed to provide stakeholders with insights into teachers' development of coherence across classrooms. Further, the study aims to identify how a shared understanding of the problem of practice and improvement science informs the principal's approach to teaching and learning. In addition, the current study endeavors to provide administrators and other stakeholders with research that informs the work of building and central office administrators in NIC development, notably when including teachers as members.

Chapter 2.

Literature Review

This chapter focuses on the literature on the traditional roles of educators in school improvement, the emerging use of NICs to address the pressures of school improvement, the various actors within a networked improvement community who are charged with school improvement, and the processes used by a NIC. Research on educational reform identifies infrastructure concerns that compete and contribute to a lack of coherence (Cohen et al., 2018). Research on school improvement also suggests a lack of sustainable progress and outlines how the traditional roles of educators contribute to these issues (Hargreaves & Fink, 2006). NICs offer one alternative approach to school improvement through multilevel collaborative structures, with some early results suggesting improved student outcomes (Huang, 2018). Research on the various actors (e.g., teachers, teacher leaders, principals, etc.) within a NIC establishes their dispositions, roles, responsibilities, and impact on school improvement work. Across the course of the literature review, I connect NIC research, leadership research, and the concept of coherence with the improvement processes used to impact school improvement to create a framework for my research. I used search engines (e.g., JSTOR, ERIC, EBSCO, Google Scholar, etc.) accessed through the Indiana University library system to select articles. I have chosen empirically grounded articles published in peer-reviewed journals. I used search terms such as NIC, teacher professional relationships, coherence, instructional leadership, and instructional coaching to guide my selection and retrieval of the literature.

School Improvement Networks

Over recent years, school improvement efforts have included school improvement networks as an emerging reform modality. These networks have been designed to focus on large-

scale improvement efforts, sometimes involving multiple organizations (Glazer & Peurach, 2013; Peurach et al., 2016; Peurach et al., 2019a). School improvement networks differ from other reform efforts because they use the entire school ecosystem to foster improvement (Peurach et al., 2016). School improvement networks can include a variety of members, such as external partners and various K-12 entities that collectively seek to improve student outcomes or advance the skills of educational leaders and teachers on a large scale (Peurach & Glazer, 2013; Peurach et al., 2016; Smith & Wohlstetter, 2001). The Success for All Foundation (SFAF) and America's Choice (AC) are examples of school improvement networks. Both SFAF and AC faced many challenges but were able to improve student outcomes significantly (Glazer & Peurach, 2012). School improvement networks such as these still face a variety of challenges, including funding and community support variability (Glazer & Peurach, 2012; Kahne et al., 2001), network initiation (Russell et al., 2017), sustainability when external supports withdraw (Joshi, 2021), and a lack of coherence (Peurach et al., 2019a; Peurach et al., 2019b). Nevertheless, researchers argue that these improvement networks are crucial in the age of required school reform focused on equitable instruction and student outcomes (Glazer & Peurach, 2012; Peurach, 2016; Peurach et al., 2019a). Given the extensive use of school improvement networks, scholars have sought ways to leverage network structures with opportunities for sustained professional learning.

Research-Practice Partnerships (RPPs)

RPPs represent one such effort and are a specific type of school improvement network commonly used to improve student outcomes. Coburn et al. (2013) specify that RPPs are comprised of elements that distinguish them from other forms of research and practitioner interactions. As Coburn et al. (2013) define them, RPPs "are long term, focus on problems of

practice, are committed to mutualism, use intentional strategies to foster partnership, and produce original analyses" (p. 2). Creating long-term partnerships provides stability in the evolving nature of K-12 education and externally imposed pressures to improve educational and student performance (Coburn et al., 2013). Part of the stability emerges because RPPs focus on establishing a problem of practice. The problem of practice serves as the focus of the partnership work and allows all stakeholders to be invested in the work (Coburn et al., 2013). Thus, research becomes a by-product of the partnership rather than the focus (Russell et al., 2017). This problem also allows external partners to help districts change if their views correspond to district authorities' views (Coburn & Russell, 2008). Partners work together using specific strategies to tackle the defined problem and create original analyses from their research together (Coburn et al., 2013). Coburn et al. (2013) define three types of RPPs: research alliances, design research, and NICs.

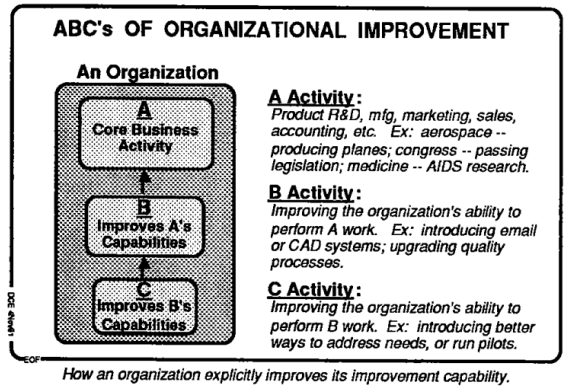
Networked Improvement Communities (NICs)

Bringing together the promise of collaboration and the importance of disciplined research and development activities, researchers have increasingly examined the utility of NICs. NICs synthesize the ideas from school improvement networks, RPPs, and other institutions using research tools and techniques from different settings such as healthcare (i.e., RCA, fishbone diagrams, PDSA cycles, etc.; Bryk et al., 2015).

Engelbart (1991) originally introduced the framework for organizations to improve. His framework posited that an organization could use a nested approach to improving "core business activity" by focusing on the work of outer layers to improve the core (Englebart, 1991; see Figure 1). His model shows how an organization could improve itself by focusing on general processes, such as improving how the institution identifies and creates solution paths.

Figure 1

Engelbart's model of organizational improvement (1991)



The concept of a NIC merges networked science, as originally articulated by Englebart (1991, 2003), and Deming's (1994) work on disciplined inquiry. Deming (1994) combines his system of profound knowledge with the deep subject matter knowledge of participants within the organization (LeMahieu, 2017). Coined by Englebart, a NIC is described as "a model of social learning that could augment collective human intelligence to solve complex problems" (LeMahieu et al., 2017, p. 6).

Englebart's *adapted* model is articulated in three tiers of social learning (Bryk et al., 2015; LeMahieu et al., 2017). The first level of learning, "A," is focused on teachers individually and their practice. The second level, "B," includes members at the organizational level and seeks to increase level "A" learning. The third level of learning, "C," engages multiple institutions in improvement work. Bryk and others have argued that "C" work delineates a NIC from other forms of institutional learning (Bryk et al., 2015; LeMahieu et al., 2017). This social learning model focuses on the various network members: teachers, district and school administrators, and outside institutions. Though Englebart (1991) notes that multiple organizations could come together to enhance the "C" level work, he also states that companies could do this without external organizations.

Additionally, an educational NIC is designed for a specific purpose. According to Bryk et al. (2015), four explicit characteristics define a NIC's function:

- Focused on a well-specified common aim
- Guided by a deep understanding of the problem, the system that produces it, and a shared working theory to improve it
- Disciplined by the methods of improvement research to develop, test, and refine interventions
- Organized to accelerate the diffusion of these interventions out into the field and support their effective integration into varied educational contexts (p. 144).

Thus, a NIC is developed with specific stakeholders to achieve a common goal.

The combined frameworks of disciplined inquiry and networked improvement aspire to "address persistent problems of practice that have resisted previous reform efforts by linking diverse kinds of expertise from research, educational design, and practice in a joint quality improvement effort" (LeMahieu et al., 2017, p. 6). This concept has the potential to be adapted to various contexts and close the gaps that currently exist within and among classrooms, schools, and districts (Russell et al., 2017). In the present study, I use the structural model of a NIC to explain how improvement work is undertaken and how actors within the district engage in sustained learning about their practice.

Researchers have articulated a framework to guide various actors in initiating a NIC (Russell et al., 2017). The NIC initiation framework includes the core work centered on solving a particular problem of practice and the three processes that focus on overcoming that problem (Bryk et al., 2015; LeMahieu et al., 2017; Russell et al., 2017). First, NIC members develop a theory of improvement that broadly describes their approach to addressing a problem of practice

(Bryk et al., 2015; LeMahieu et al., 2017; Russell et al., 2017). Further, NIC members use disciplined inquiry to determine what works, for whom, and in what context (Bryk et al., 2015; LeMahieu et al., 2017; Russell et al., 2017). Finally, they build the infrastructure for measurement and analytics to assess the implemented theory (Bryk et al., 2015; LeMahieu et al., 2017; Russell et al., 2017). Russell et al. (2017) use an analysis of case studies to postulate the importance of this framework in initiating the development of a NIC and address some of the inherent challenges. Russell et al. (2021) expand this framework and define NICs as scientific professional learning communities that can enhance an understanding of the NIC development framework.

A NIC requires nuanced collaborative relationships that cross the hierarchy of traditional roles and institutions. This path differs from what has previously been attempted in most education reforms. School improvement networks are traditionally comprised of external partners, often nonprofits and universities, and members of multiple layers of K-12 institutions (Glazer & Peurach, 2012). It bears noting that NICs do not require external partners to exist (Englebart, 1991; Kallio, 2020). Instead, school districts can establish NICs within their organizational structures. Joshi et al. (2021) analyze one NIC and note that the network narrowed when external supports were removed; however, they indicate that the essential components of the network remained. It is paramount that a NIC includes multiple stakeholders across an organization to engage in accelerated improvement work. This work includes iterating specific change ideas and coordinating learning across organizational levels. Proger et al. (2017) echo this point, noting that it is essential to build "a cohesive team with participants representing different types of expertise" and embed "capacity building to develop additional expertise" (p. ii).

Furthermore, a NIC is susceptible to the various changes within and between organizations and the policies those organizations must adhere to (Glazer & Peurach, 2012). One such case study, the Mathematics Teacher-Education Partnership, illustrates the complexities of organization, operations, and leadership across a network when it is added to an existing organizational structure (Martin & Gobstein, 2015). Extending the learning from Bryk et al. (2015), Martin and Gobstein (2015) suggest that a NIC must continue attending to its needs and be adept at changing through the evolution of a network. Their research is a single case study based solely on organizing, operating, and leading a network. Russell et al. (2017) also note that an emerging network must include a "culture, norms, and identity" to encourage participation both initially and across time (p. 25). However, neither study addresses the perspective of the teachers included within it nor how members within the group cohere in evolving learning. Leaders and members of educational communities must carefully consider all the nuances of the network those educational entities create and work to foster its coherence and growth. Although NICs seek to create a well-focused response to complicated problems, the literature lacks a review of the challenges of creating coherence across a network.

In their research, Peurach et al. (2016) provide an evaluative framework that appraises the effectiveness of such improvement communities; they argue that continuous improvement deepens when operating conditions, collective learning supports across the community, and effective human capital strategies coalesce (Peurach et al., 2016). Peurach (2016) takes this further by conducting one case study on the complexity involved. However, he documents that research has yet to determine "what works, for whom, and under what conditions" (Peurach, 2016, p. 426), indicating a need to consider stakeholders' perspectives within a NIC. Others, such as Bryk et al. (2015), additionally highlight that NICs must consider various contexts.

Including stakeholders with different areas of expertise, clarifying roles, and developing continuous improvement capacity are specific human capital strategies when developing and sustaining a NIC that add to the understanding of creating an improvement community (Proger et al., 2017). However, the authors caution that their research does not address sustained effectiveness across time or contexts (Proger et al., 2017).

Gomez et al. (2016) suggest that the primary goal of a NIC is to accelerate problem-solving and spread innovations to achieve network aims. NICs diverge from previous school improvement reform and offer a new means of accelerated learning (Bryk et al., 2015). One example is the creation of the Statway NIC, which was designed to improve community college students' mathematics results (Bryk et al., 2010). Initially, Bryk et al. (2010) use this NIC initiation to introduce a new type of research and development system across a dynamic group of actors. According to Huang (2018), the Statway NIC has demonstrated that NICs can successfully work together to improve college student outcomes in mathematics (Huang et al., 2016; Sowers & Yamada, 2015).

Another example is the Math Teachers Education Partnership NIC, which was created to prepare future mathematics educators better. Martin and Struckens (2018) have completed a case study on one branch of this consortium, a "research action cluster" (RAC) focused specifically on improving clinical experiences. Their findings support that NIC formation and processes can be advantageous in helping college students strengthen their preparation to become mathematics teachers (Martin & Struckens, 2018). Although the NIC concept has had some documented success at the collegiate level, the impact of NICs on achievement at the elementary school level has not yet been researched.

As research on NICs continues to develop, some researchers have sought to understand how NICs can be developed through state-level agencies and spread to districts across a K-12 system. For instance, Penuel et al. (2018) study a NIC that included 13 states who used improvement science to focus on equity and coherence in science education. The goal was to develop a coherent vision and framework to implement in districts across all 13 states (Penuel et al., 2018). The authors contend that NIC members must have a subject-specific vision and include actors with "subject matter expertise and pedagogical content knowledge" to succeed (Penuel et al., 2018, p. 35). Although the authors contend that it is essential to lead for equity and coherence across leadership levels (Penuel et al., 2018), their description does not fully elaborate on how actors within the NIC have worked together to achieve this aim. Indeed, this remains an important gap in the literature on developing and using NICs.

In another study, Cannata et al. (2017) look at a specific NIC designed to affect positive change at the high school level. Their research provides information about how teachers in collaborative teams were focused on a particular aim and found some success in their work (Cannata et al., 2017). Their work provides a window into the impact of the partnership on high school teachers who were part of the NIC. Specifically, teachers had an increased sense of success and a better understanding of the work of district-level administration (Cannata et al., 2017). This article provides research on one improvement community aimed at high school improvement. Another case study focusing on secondary mathematics sought to determine how a NIC is established and how to prepare members for "successful participation" in terms of the use of improvement science processes within the NIC (Rohanna, 2018, p. 139). Rohanna (2018) deems the network successful but notes that variation across the network existed. Both studies add to the literature on secondary NICs.

A recent study of a statewide NIC in Tennessee has assessed the initial understanding of a literacy problem of practice in addressing reading deficiencies (Fillers, 2019). The focus of the study centered primarily on adults' sensemaking of the problem of practice after it was defined. The research provides insights into the problem the NIC defined and process they used to grapple with the topic to understand the problem better; however, the study does not address how the participants move beyond sensemaking into action to address the deficiencies in reading. This study provides a glimpse into a NIC centered at the elementary school level.

The Regional Educational Laboratory at American Institutes for Research (REL Midwest) established two NICs, one in Minnesota and the other in Michigan (Proger et al., 2017). Though both NICs were designed to address achievement gaps in some way, the research in this study mainly focuses on the tasks necessary for establishing a NIC. The researchers note that RCA was used with the Michigan NIC, and they identify a problem of practice in math fluency. Because the research focuses on NIC establishment and processes, the study does not address how addressing time in fluency impacted student learning.

In a separate study in the Bronx in New York, a researcher implemented a NIC to support instructional leaders in improving math outcomes for grades K-8 (Rudolfo, 2023). The study centers on using improvement science tools and processes within the NIC. Though the study shows improved use of IS, the researcher notes the inability to gather data from teachers or student outcome data. Given the emerging studies of NICs, there are still few studies about NICs that include elementary school mathematics teachers and their roles or impact on student outcomes.

Surprisingly, research has yet to widely discuss how NICs might contribute to coherence within instructional programs. The coherence process necessary for a NIC to function requires

more than an alignment of resources. Instead, the concept of coherence includes balancing external demands with schools' work to achieve the schools' aims (Honig & Hatch, 2004). The myriad of actors in a NIC are included to support the school and achieve a specified aim. However, rather than provide a single program with expectations of coherence, the school must balance various inputs to accomplish its goals (Honig & Hatch, 2004). All members of a NIC, including the local education agency and external participants, must continuously seek to create coherence. This literature has focused on leadership, higher education, and secondary education in NICs. More recently, Peurach et al. (2019b) have offered a view of coherence and how competing interests may impede it. They argue that, rather than a bridging and buffering system (Honig & Hatch, 2004), the networked system becomes a sharing system between schools and the central office (Peuarach et al., 2019b). Essentially, they describe a looped system where the best ideas in a subset of schools are refined, tested, and distributed to the entire district, where it is taken up to address the problem (Peurach et al., 2019b). Thus, the networked system builds a coherent instructional system across schools. This stream of the literature provides additional insights into coherence for literacy. However, few studies focus on coherence at the K-5 level in mathematics.

Roles and Responsibilities of NIC Members

NICs can be created by a network initiation team comprising several types of members: nonprofits, district administrators, building administrators, coaches, and teachers. Each member serves a unique function in the NIC while also serving in their traditional roles. I draw on the literature in the subsections below to explain these integral NIC members' dispositions, functions, and responsibilities.

A network initiation team can establish a NIC and is responsible for several actions. The network initiation team includes the initial members who begin the work of a nascent NIC. At the outset of NIC development, the team functions to establish the network. This team collectively determines the problem that will be solved (Bryk et al., 2015). Based on this problem, the group sets about recruiting members with the needed expertise to facilitate the work of improvement (Bryk et al., 2015; Russell et al., 2017; Rohanna, 2018). According to Biag and Sherer (2021), "educational improvers engage in disciplined inquiry, adopt a learning stance, take a systems perspective, possess an orientation toward action, seek the perspective of others, and persist beyond initial improvement attempts" (p. 1). When seeking to create a NIC, finding members with these dispositions can help foster the development of the NIC. This team must obtain the necessary funding and provide improvement science expertise to the NIC (Bryk et al., 2015; Dolle et al., 2013; Peurach & Gumas, 2011; Russell et al., 2017). Specifically, the initiation team uses the tools and processes of improvement science to analyze the current reality and establish a measurable aim and working theory of practice (Bryk et al., 2015; Russell et al., 2017; Rohanna, 2018). In addition, members must facilitate communication and provide analytic support and infrastructure (Bryk et al., 2015; Rohanna, 2018; Russell et al., 2017). This team further coordinates the work through a hub (Bryk et al., 2015; Russell et al., 2017).

Nonprofits, most commonly in the form of university personnel, are often the network providers—or hub coordinators—providing executive leadership (Dolle et al., 2013; Glazer & Peurach, 2012; Peurach, 2016; Peurach & Gumus, 2011). Network providers can be defined as "sponsoring organizations that establish and arrange instructional networks and that function as their hubs" (Glazer & Peurach, 2012, p. 681). Members of these organizations provide *executive leadership*, which according to Peurach and Gumus (2011), means they "…bear ultimate

responsibility for establishing, managing and sustaining the hub organization and the network" (p. 3). Peurach and Gumus (2011) note that executive leadership practices are weakly articulated and understood. Rohanna (2018) also views executive leadership beyond the roles of coordinators and sustainers, instead as individuals who bring expertise. The expertise could be academically based (e.g., improvement science or the problem of practice subject) or relationally based, explicitly building relationships with practitioners. The research of Proger et al. (2017) supports the need for content and context experts as part of a cohesive NIC. The literature has shown much authority given to university personnel, but there has been no discussion of how their roles and responsibilities shift when district personnel takes the lead.

Another function of nonprofits, including universities, is to enlist the help of researchers. Peurach (2016) posits that researchers can access network providers and support the work of the NIC. The specific work of researchers includes bolstering the NIC infrastructure (Dolle et al., 2013; Peurach, 2016) and working with other members to "identify, understand, and address their problems of practice" (Peurach, 2016, p. 426). Specifically, researchers present the context of scholarly literature to understand problems of practice and address them in new ways. Cannata et al. (2017) expand this theory to implementing the researcher role through a case study. In this instance, researchers behave "as intermediaries between the worlds of educational research and practice" (p. 581). In other words, researchers translate research into practical terms for use in the decision-making and capacity-building of the NIC and its members (Cannata et al., 2017; Thompson et al., 2019). Researchers also provide knowledge of improvement science and its tools (Rohanna, 2018; Thompson et al., 2019). Proger et al. (2017) also note that researchers support analysis and data collection efforts. Furthermore, researchers inform central office

personnel through summative reports that synthesize the learning of the NIC (Thompson et al., 2019).

Central office administrators' roles and responsibilities in NICs have limited discussion in research. Peurach and Gumus (2011) note that executive leadership roles may overlap with the functions of district administration and conceptualize the knowledge and practices of executive leaders. However, the authors note that little is known "about the differences (if any) between the practice knowledge and learning of network executives and executives in public education agencies" (Peurach & Gumus, 2011, p. 4). Cannata et al. (2017) further expand on the role of district personnel. The authors note that central office administration allocates resources and determines alignment to the district vision and any potential restrictions to the work of the NIC (Cannata et al., 2017). In addition, senior leadership selects NIC members and orients the school-level teams to the work's process, content, and analytics (Cannata et al., 2017). Additional research provides insights into the tasks of district facilitators, such as supporting school teams through PDSA coaching and data support (Russell et al., 2017; Thompson et al., 2019). However, the district administrator's role of building coherence through buffering and brokering specifically for NIC work is not expressly addressed.

School administrator roles in NICs are defined by the specific NIC in which they or their staff participate. In a comparative case study including teachers from PreK-12, Hannan et al. (2015) note variations in the execution of the principal's role across the network. The role described was connected explicitly to the principal's function at the school level. The principals in the network had varied levels of PDSA implementation, data usage, and learning application that contributed to their teachers' success level (Hannan et al., 2015). In a high school case study, Peurach et al. (2016) note that principals in a large-scale NIC are charged as change agents in the

high schools they serve. Specifically, they broadly function as liaisons between the hub, community, students, and teachers while managing the school's instructional system (Peurach et al., 2016). In another NIC focused explicitly on the work of high school mathematics, the author articulates essential network tasks of principals: providing time, space, and coverage necessary for the collaboration between network leaders and teachers (Rohanna, 2018).

Principals may sometimes not participate as initially intended, so the NIC community is called upon to ideate solutions. For instance, Cannata et al. (2017) share a lack of principals' inclusion on the District Innovation Design Team out of concern that principals might impede the innovation of teachers included on the team. Thompson et al. (2019) note that a high school science NIC incorporated learning walks in year three because of a lack of participation of principals in the network. Even with this research, there is scant research documenting the elementary principal's role in a NIC, especially considering the critical role principals play in school reform.

There is some research on the roles and responsibilities of coaching in a NIC. In each instance, coaching has been enacted in two main ways: coaching on improvement science processes (i.e., driver diagrams, RCA, fishbone diagrams, etc.) or specific content that centers the work of the NIC. Some initial research suggests that coaching is one way to develop improvement dispositions (Biag & Sherer, 2021). Russell et al. (2017) articulate how coaching was enacted with a nascent NIC. In this instance, coaching on coaching was used to support the implementation of PDSA cycles. In a statewide NIC supporting alternative learning, coaches from the external partner facilitated meetings to coach on using IS to analyze the root cause of challenges in credit recovery and develop both an aim statement and a driver diagram (Margolin et al., 2021). Margolin et al. (2021) evaluate NIC implementation, including an evaluation of

meetings defined as coaching/consultation sessions. Their findings have indicated the participants' perceived usefulness of coaching sessions while also illustrating the various preferences in coaching (Margolin et al., 2021).

Similarly, two case studies have noted that network executives provided coaches and are not affiliated with the school district (Peurach et al., 2016; Rohanna, 2018). In one instance, the coaches provide an overall vision, minimal support for new principals, and limited interaction with the schools because of several limiting factors (Peurach et al., 2016). Conversely, the other coach is focused on setting an instructional vision of high school mathematics and providing professional development that aligns with that vision and the network drivers (Rohanna, 2018). A third case study offers some insights into the role of district-provided coaches. In this instance, the coaches facilitated professional development and coaching with science teachers while meeting weekly with researchers to debrief and plan future learning opportunities (Thompson et al., 2019). Research on the roles and responsibilities of a coach in an elementary mathematics NIC is limited, especially considering the vast literature that articulates the influence coaches can have on school improvement.

Teachers typically design and implement instruction to increase student learning. As end users, their roles in a NIC are essential to understand. Previous NIC research has focused on improving novice teachers' skills rather than their roles and responsibilities in the NIC (Hannan et al., 2015). In addition, the research has shared the skills of leaders in providing feedback to novice teachers in the NIC (Hannan et al., 2015). Teachers in a large-scale high school NIC had defined roles and responsibilities that aligned precisely with the hub's aim: implementing project-based learning (Peurach et al., 2016). In the case of a year one high school NIC, leaders tasked teachers with learning improvement science in the context of math instruction and

applying it to their work (Rohanna, 2018). Rohanna (2022) also posits that teachers use evaluative thinking to "foster deeper reflection" about those applications (p. 62). This research suggests that an additional teacher responsibility is to learn and apply improvement science in a practical context while engaging in deep reflection. The research thus far has not been extended to improving science at the elementary school level, leaving one to wonder how an elementary school teacher would use it in a practical setting.

Teacher roles have been expanded in more established NICs. For example, one additional teacher role—the teacher leader—was introduced to an established (Year 4) NIC and was designed to spread peer coaching of science best practices (Thompson, 2019). The current literature has focused on the roles and responsibilities of secondary teachers (Peurach et al., 2016; Rohanna, 2018; Thompson, 2019). However, current research on NICs has not established the roles and responsibilities of elementary school teachers. Furthermore, there has been little research on elementary mathematics instruction in the NIC literature.

The Importance of Principals, Coaches, and Teachers in a NIC

The importance of the principal as a leader has been established for some time. Hallinger and Heck (1996) have conducted a meta-analysis of the empirical literature, finding that principals who focus on school processes, including school goals and academic expectations, have an impact. In another study, the authors determine that principals have a statistically significant indirect effect on student achievement (Hallinger & Heck, 1998). Other researchers have provided information about what traits or behaviors increase student outcomes. For instance, previous research by Copland and Knapp (2006) suggests five important actions to improve learning: focusing on teaching and learning, creating professional learning communities, enlisting external groups when appropriate, using shared, strategic leadership, and creating

coherence through the connection of learning goals. More recently, Hitt and Tucker (2016) have synthesized instructional leadership frameworks that included five effective leadership categories: "establishing and conveying the vision, facilitating a high-quality learning experience for students, building professional capacity, creating a supportive organization for learning, and connecting with external partners" (p. 542). Each of these frameworks identifies many of the same characteristics and practices. An analysis of recent leadership literature by Lochmiller and Cunningham (2019) finds that shared leadership, including teachers, teacher leaders, and coaches, is essential to improving student outcomes in math.

Instructional leaders can emerge in various roles in schools. Neumerski (2013) synthesizes the instructional leadership literature of principals, coaches, and teachers. Her findings suggest that empirical research across the three domains of leaders enhances understanding of teaching and learning (Neumerksi, 2013). She further synthesizes the behaviors of instructional leaders linked to teaching and learning. As she notes, however, a gap remains in the interactions between instructional leaders and teachers and how those interactions impact teaching and learning (Neumerski, 2013). Instructional leaders and teachers are essential actors in a NIC and contribute to the NIC's ability to produce a coherent instructional program. However, various actors may not equally contribute based on their roles or responsibilities. Thus, it is essential to understand the traditional roles of instructional leaders and teachers and their contribution to improving student learning.

Principals as Leaders

Principals are often viewed as change agents within a school building. Over the past several years, these building administrators have been charged with becoming instructional leaders. Research points to classroom observations with feedback as a meaningful way principals

impact instructional improvement (Leithwood, 2012). However, building leaders do not always have the necessary content and pedagogical knowledge to do so. In one study, teachers self-report that the feedback provided by principals was unlikely to improve instructional practices (Rigby et al., 2017). Further, the study concludes that resources must be "invested to support administrator learning" to increase the likelihood of meaningful instructional improvement (Rigby et al., 2017, p. 508). Another study has determined that support for administrators could enhance their ability to provide relevant feedback to teachers and improve their instructional leadership skills (Lochmiller, 2016). The research suggests a different approach is needed to enhance principals' instructional leadership effectiveness.

In some instances, districts have assigned executive-level district leaders to support roles to assist principals in becoming instructional leaders (Honig, 2012). These district leaders act as supervisors and coaches for principals to improve student outcomes and instructional practice within their schools. The duality of this role creates challenges for coaching principals (Lochmiller, 2018). District leaders who function in this role have likely had various experiences as administrators and hold their own beliefs about how best to create instructional leaders and need to know which practices improve principal instructional leadership. Specific techniques have been elevated as more robust support for principals. Honig (2012) states these practices include a "joint work approach" (p. 745), consist of differentiated support, are modeled using metacognitive strategies, use tools, and broker and buffer supports outside the school setting. However, there is no mention in the research on creating coherence across schools that an executive leader or leaders support, nor is there a discussion of how this might affect working to solve a shared problem of practice.

Instructional Coaches as Leaders

One district mechanism to support instructional changes is using instructional coaches (Mangin & Dunsmore, 2015; Woulfin & Rigby, 2017). Many districts employ coaches to bolster teacher learning, which can increase student outcomes. Coaching is "alternately framed as a means for systemic and individual reforms" (Mangin & Dunsmore, 2015, p. 181) and, thus, may not necessarily be tightly aligned to district systemic reform (Desimone & Pak, 2017; Mangin & Dunsmore, 2015). The multiple ways in which instructional coaching is executed suggest that variation in implementation can occur. This type of variation causes one to consider the inconsistencies in instructional coaching expectations and performance, which could lead to various outcomes for the students being served.

Instructional coaches need specific knowledge and skills to enact reform within a district. Woulfin and Rigby (2017) argue that systemic alignment requires coaches "develop shared understandings, model practices, and broker ideas to facilitate the aligned enactment of evaluation and instructional reform" (p. 326). In one case study, Gibbons and Cobb (2016) describe coaching practices and what knowledge is implied within these practices as beyond that of an "accomplished teacher" (p. 256). Specifically, they identify having a shared problem of practice rather than individual coaching and a coach-driven goal to assist teachers in developing ambitious teaching (Gibbons & Cobb, 2016). Another study conceptualizes instructional coaching through the five key features of effective professional development but notes that additional research is needed to determine the value of coaching within this context (Desimone & Pak, 2017).

The current research provides various coaching models and distinguishes some needed characteristics. However, there is a lack of evidence of coherence across these characteristics. Furthermore, coaches are not always available to support teacher learning or create coherence

across schools or the district. Thus, teachers are the sole consistent actors in gaining coherence across classrooms and have a more significant direct impact on student learning. Because teachers are in classrooms daily and have the closest touch point to student learning, it is essential to consider their role in school improvement and increased student learning.

Teachers as Agents of Classroom-Based Change

Teachers' classroom practices are essential for school improvement. However, isolated teachers are unlikely to create significant progress that has a lasting impact across the system (Russell et al., 2017). Teachers desire empowerment in their learning and implementation strategies within their classrooms. However, teacher empowerment only indirectly affects instructional practices and may or may not create improvement (Marks & Louis, 1997). Furthermore, significant variability exists in implementation and student outcomes when teachers work in isolation (Russell et al., 2017). Thus, the opportunities that align to a common purpose that is extended over time can be integrated into their teaching and connected to the work of other teachers, hence creating an increased commitment for a teacher (Newman et al., 2001). In addition, each teacher needs to build, alter, and expand their professional capacity, including working relationships, pedagogical skills, and content knowledge (Sebring et al., 2006). Indeed, for teachers to be agents of change, their professional relationships must be considered.

Many organizations utilize professional learning communities to create meaningful change and increase professional capacity. Sebring et al. (2006) note that professional teacher communities are an essential component of school improvement and can be used to "address the core problems of practice" and create shared responsibility in solving these problems (p. 13). Fullan (2016) broadens the thinking and expands beyond the previously defined professional

learning communities to networks, highlighting that deep learning combines with collaboration to create solutions. Additionally, the author notes that this type of professional learning changes the kind of relationship within a hierarchy (Fullan, 2016), connecting it to coherence as a continual process. The professional communities of teachers and their practice are worthy of growth and development (Stoll et al., 2006). However, professional learning communities do not always have a shared common understanding of a process, language, or means through which they can collectively tackle a problem of practice and reach their aims (Horn & Little, 2010). Teachers who filter information from one another and other settings create this lack of understanding (Coburn, 2001). In observed settings, professional learning communities focus on small, short-term solutions that may not connect to the more significant needs (Van Lare & Brazer, 2013), hindering understanding and possible replication.

Several characteristics work together in positive professional teacher communities and connect to coherence (Honig & Hatch, 2004) and the work of NICs (Bryk et al., 2015). Trust is essential in a professional teacher community (Bryk & Schneider, 1996; Bryk & Schneider, 2002). Further, Bryk et al. (1999) highlight three additional necessary elements: "reflective dialogue among teachers about instructional practices and learning; a deprivatization of practice in which teachers observe each other's practices and joint problem solving is modal; and peer collaboration in which teachers engage in actual shared work" (p. 753). Teachers who negotiate problems of practice, alter instructional routines, and take on new learning opportunities provide additional professional learning potential (Van Lare & Brazer, 2013). Nonetheless, there is still significant variability within professional teacher communities (Coburn & Russell, 2008; Russell et al., 2017).

Teacher Leaders

Teacher leaders might offset professional relationship issues and help with increasing professional capacity. Wenner and Campbell (2017) define teacher leaders "as teachers who maintain K-12 classroom-based teaching responsibilities while also taking on leadership responsibilities outside of the classroom" (p. 140). Though no widely accepted single definition of a teacher leader exists, Wenner and Campbell's working definition most closely aligns with the criteria of teacher leaders in the present study. This definition provides a distinction from instructional coaches who do not maintain their own K-12 teaching responsibilities. Some studies suggest that teacher leaders can impact school improvement (Muijs & Harris, 2006; Smylie et al., 2002), though one case study cautions that changes in teacher leaders might impede long-term efforts (Joshi et al., 2021). Neumerski's research (2013) finds that the literature on teachers as instructional leaders mainly provides descriptive knowledge of characteristics and behaviors without giving insights into how teachers might enact an instructional leadership role within a professional learning community (PLC). However, Harris (2013) expands the research to develop what those roles might entail. Harris (2013) suggests that relationship building, using expertise, collaborating and fostering coherence, and brokering improvement into practice are four emerging roles but cautions that additional research in these areas is needed.

Concept of Coherence

Honig and Hatch (2004) conceptualize coherence as the means the central office and schools use to determine which strategies and goals will advance their organization. The researchers define the variables that work together to create coherence across both groups. They also define a set of strategies and goals of coherence, including creating and maintaining "collective decision-making structures," as well as management of information (Honig & Hatch,

2004, p. 21). The authors use previous research to further describe these structures through the specific activities, capacities, and conditions leaders create or use to advance the work (Honig & Hatch, 2004). Indeed, recent research confirms that certain leadership actions such as improving or enhancing instructional programs are more effective in improving teaching and learning (Hitt & Tucker, 2016; Leithwood et al., 2020). However, there is a need for further research on what practices principals implement, how they are implemented, and the effect of those specific practices (Leithwood et al., 2020). Some reform policies are designed to build coherent alignment of standards, instructional programs, and assessments at the state, district, or school level (Newmann et al., 2001; Smith & O'Day, 1990). The concept of coherence, defined by Honig and Hatch (2004) as a "dynamic process" (p. 16), is distinctly different from alignment.

For the present study, some, critical structures of coherence aligned with leadership actions as outlined by Honig and Hatch (2004) are defined. Specifically, I include principal leadership (Newman et al., 2001), developing and maintaining professional teacher communities (Coburn, 2001), and the use of data (Datnow & Stringfield, 2000) aligned to the emerging work of a NIC's ability to gain and maintain coherence. Coburn (2001) discusses the potential for using informal and formal structures and teachers' conversations to develop coherence. Also of note is the author's suggestions that collaboration for authentic purposes and providing access to human and written resources can help teachers gain additional knowledge when learning a new practice in their classroom setting (Coburn, 2001). Recent research by Hitt and Tucker (2016) continues to articulate the importance of developing structures for collaboration. Honig and Hatch (2004) also note that continuing staff development is a structure for maintaining collective decision-making. Data collection, analysis, and use of data to inform decisions (Datnow & Stringfield, 2000) are critical to information management. However, educators may not have

adequate training to support data-driven decisions (Jimerson & Wayman, 2015). Thus, the importance of several characteristics and structures designed for improvement runs across the literature on instructional leadership and coherence. The conditions necessary for coherence, as defined by Honig and Hatch (2004), provide a lens through which to evaluate instructional leadership and the development of a NIC.

NIC Improvement Tools and Processes

Practicing educators seek to improve the quality of education for their students, and here, professional capacity is essential. Bryk et al. (2010) note that this area includes the "social resources within a staff to work together to solve local problems" (p. 24). He and others extend this thinking to using NICs to improve professional capital (Bryk et al., 2015; Russell et al., 2017). The members of NICS utilize various tools for network improvement to increase capacity and continuously learn and improve. NICs also expand learning beyond the classroom or school level and implement changes across multiple contexts. For instance, one study illuminates the use of improvement science processes in education to improve attendance in five secondary schools with a statistically significant impact (Daley, 2017).

One disciplined inquiry tool used to determine the scope of work for a problem is an RCA (Bryk et al., 2015). One study examining two NICs uses an RCA to identify and narrow a problem of practice that NIC participants found important (Proger et al., 2017). The authors note that the use of RCA for this purpose and to ensure that members of the NIC could address the problem are essential components of the work with those NICs (Proger et al., 2017). Though this research is limited to two educational NICs, the study suggests how vital an RCA is in defining the problem that needs to be addressed.

The analytic engine of the NIC framework used to create structured inquiry is the PDSA cycle (Bryk et al., 2010; LeMahieu et al., 2017). The PDSA cycle is an iterative method whereby NIC members identify a problem, implement a change idea, study the results, and determine the following steps to improve (Bryk et al., 2010; LeMahieu et al., 2017). This method allows the members of a NIC to test a change idea multiple times in various contexts (Bryk et al., 2010; Russell et al., 2017). Each PDSA cycle is completed, and decisions are made for the next iteration, ultimately building "more effective practices" and "deeper learning" (Bryk et al., 2010, p. 27). Further, the PDSA cycle allows NIC members to study what is implemented and determine where and for whom a particular intervention works or does not (Bryk et al., 2010). The Building a Teacher Effectiveness Network (BTEN) case specifically illustrates using the PDSA cycle to tackle the complex problem of effectively supporting novice teachers (Hannan et al., 2015). The BTEN comparative case study shows how the schools implemented improvement science in varying degrees, but the researchers also note that the approach "holds promise for implementing innovation in educational settings" (Hannan et al., 2015, p. 506). Proger et al. (2017) have reviewed two NICs, determining that the problem must be one that members find and that can be acted upon. However, their research does not assess the impact of the work (Proger et al., 2017).

It is also important to note that implementing a PDSA cycle is not a panacea. A study of two school districts identifies the opportunities and challenges in professionals' responses to the PDSA cycle for improvement (Tichner-Wagner et al., 2017). A study of teacher agency in using improvement science tools notes that, although teachers found the tools helpful, they "struggled to engage in iterative inquiry" aligned with the process (Sharrock, 2018, p. 84). In addition, a case study finding shows that, although the teachers in the study valued systems thinking, they

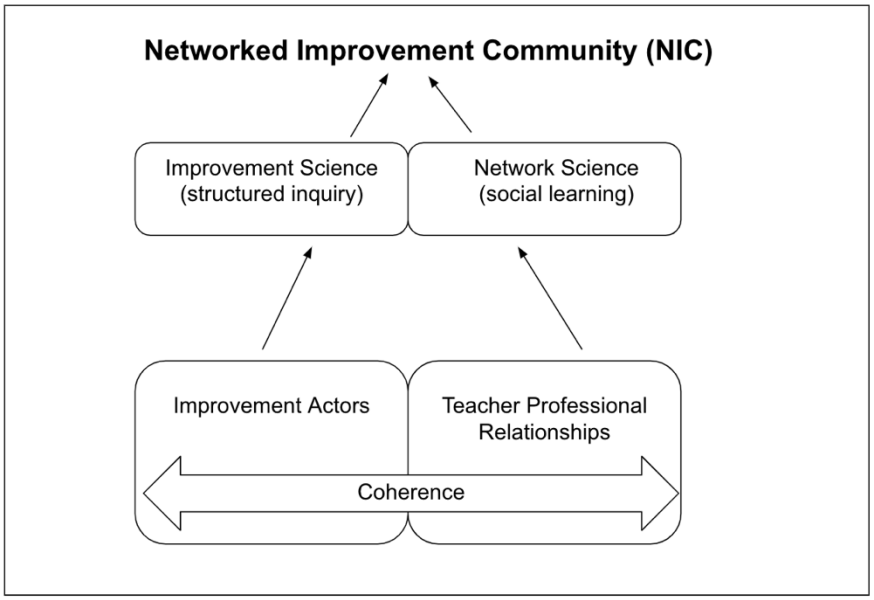
failed to use data in PDSA cycles to inform the inquiry process (Hill, 2019). Additional research in using improvement science processes to improve teaching and learning is still needed.

Theoretical Framework

Research across contexts in the present literature review suggests interconnectedness between instructional leadership frameworks, traditional roles of educators, NICs and their members' roles, and the processes used to achieve results. Previous research by Honig and Hatch (2004) conceptualizes the concept of coherence as several variables that work together to create coherence across leadership groups. However, the authors recognize that additional research on the presented variables needs to be conducted in the context of schools (Honig & Hatch, 2004). This study's theoretical framework is formed using the concept of coherence as a set of variables occurring during the interactions among the NIC actors, which include professional teacher relationships. The variables will also be applied to situations when the actors use the structured inquiry of improvement science and the social learning of network science to function as a NIC. Taken together, these concepts form my research framework (see Figure 2). My research seeks to extend the nascent literature on NICs by considering the variables in the concept of coherence as they apply to instructional actors of an emerging NIC.

Figure 2

Illustration of theoretical framework



Chapter 3.

Methodology

I completed a qualitative case study (Yin, 2018) using data collected from two schools in an urban school district in the Midwestern United States. I chose this method because I sought to understand the implementation of improvement science and how it was applied to the specific context of my research participants. Additionally, a case study was relevant, given my reliance on multiple data sources and a method of triangulating evidence (Yin, 2018), as outlined in my study design. I designed my study to understand how, if at all, an emerging NIC would increase coherence in instructional practice across classrooms and schools in an urban school setting. I further wanted to understand how this work informs the principal's approach to teaching and learning. I completed a retrospective study of the nascent NIC because of the pandemic. I conducted interviews and focus groups with principals and classroom teachers, observed improvement meetings and professional development sessions, and retrieved documents. My analysis was completed using the six-phase process of Braun and Clarke (2006). The study began in November 2020 and concluded in June 2021. Below, I describe the study design and conclude by noting its limitations. The present study sought to answer the questions:

- How do teachers engaged in an emerging NIC use an RCA to promote a coherent understanding of the problems they are facing in their classrooms, if at all?
- How do repeated testing cycles through a PDSA contribute to the teacher's understanding of the problems they are facing?
- In what ways does the shared understanding of a problem of practice derived through the RCA and PDSA better inform the principal's approach to improving teaching and learning?

Research Setting

I conducted the research in two elementary schools in a large urban school district in the Midwestern United States. The schools were selected because of their involvement in a university/district partnership, which sought to establish a NIC focused on elementary mathematics. Senior leaders selected the schools for participation in the partnership since they were not involved in other district initiatives. Principals in the schools were invited to recruit teachers to participate in the NIC that was being formed. The selected schools had differences in their demographics, teacher experience levels, and student populations. In addition, each school was located within unique settings in the district (i.e., urban, suburban, rural) because the district serves the entire county. Table 1 shows the characteristics of the schools involved in the study.

Table 1

Characteristics of the Schools

School Demographics	Rolling Hills		Main School	
Enrollment	505		428	
	n	%	n	%
Student Demographics				
Asian/Pacific Islander	1	0.2	9	2.1
Black	5	0.9	101	23.6
Caucasian	464	91.9	227	53
Hispanic	13	2.6	31	7.2
Multiracial	22	4.4	59	13.7
Native American/Alaska Native	0	0	0	0
Free or reduced-priced lunch eligible	187	37.0	399	93.2
Student eligible for special education	49	9.7	94	22
Students with limited English Proficiency	0	0	13	3
Teacher Demographics				
Total number of classroom teachers	29	100	39	100
Number of teachers with 5 or				

fewer years' experience	4	13.8	13	33.3
Number of teachers with more than 5 years' experience	25	86.2	26	66.7

Research Participants and Sampling Strategy

Schools recruited to the partnership NIC were used in the study, creating a convenience sample (Bornstein et al., 2013). The study included two principals and four teachers, creating a purposeful sample (Patton, 2002). Each of the two principals led a school that is part of the elementary mathematics NIC that began during the 2018–19 school year. The principals participated for two years in the NIC. The principals had an average of 4 years of professional experience as school administrators. The sample included two female principals. In addition, I recruited classroom teachers who were members of the mathematics NIC. The sample consisted of teachers who were both experienced and novice math educators. All four teachers were female. Three teachers participated for two years in the NIC, and one teacher participated for one year in the NIC. Any teacher who taught at one of the elementary schools but was not a member of the emerging NIC was excluded.

Positionality

My positionality encompasses several facets of who I am as an educator and person. Two aspects are at the forefront of this work: my coaching roles during my tenure and my current role as a district administrator. I currently serve as a district administrator and one of the leads in the partnership where I am conducting this research. My role in the partnership could lead to implicit and explicit bias if I am not highly cautious. As a district leader, I support and lead others toward increased student achievement. My knowledge of curriculum and pedagogical best practices influence my beliefs when I observe in classrooms and speak with teachers, principals, and district administrators. The constant balance of coach and district administrator roles influences

how I interact with staff and students within classrooms, buildings, and the district. My known job responsibilities affect how various stakeholders interpret my coaching feedback. I was explicit in my conversations that this was a coaching conversation, and I acknowledged that we were building an understanding of this new learning together. However, my district role means I have positional authority over some stakeholders. Thus, I used a stated coaching and learning stance to manage the conflicts this authority poses.

Given my role within the district, my previous work with some participants, my responsibilities within the partnership, and my role as a doctoral student, I needed to carefully consider how I collected and analyzed the data to avoid implicit and explicit bias. Thus, I stepped back from my district role and entered a different space as a researcher. Maintaining a neutral stance when observing and conducting interviews was essential to my work. Further, I needed to consistently consider how my previous role and the NIC work aligned and did not align to ensure that bias did not creep into the research and data analysis. I have a deep understanding of the context within which I was researching. The historical and personnel perspectives were critical to the work. However, these perspectives could create bias. I could make inaccurate assumptions based on my experiences. Thus, I had to reflect on my thinking throughout the process to make explicit any potential biases.

To mitigate my biases, I based my analysis on recorded participant responses that reflected their exact statements or experiences. I used documents and artifacts to corroborate information provided by principals and teachers during interviews and focus groups. In addition, I used specific quotes and information from the interviews, focus groups, documents, and artifacts to corroborate my interpretations and claims regarding the data. When reviewing my

work, I sought to identify and remove statements that reflected "insider knowledge" and preface claims with my role in the process, when needed.

Data Collection

Data collection consisted of interviews, focus groups, documents, and artifacts. I conducted semistructured interviews and focus groups with administrators and classroom teachers in the two schools. In addition, I reviewed pertinent documents or artifacts, including summary documents I created during team meetings at each school. Throughout the interviews, I wrote reflections during and after my experiences with the principals and teachers. The reflections captured my impressions of the interviews, including participant emotions, connections I made to artifacts, and other notes about what needed to be triangulated with other documents and interviews.

Interviews

Semistructured interviews of principals from the two schools were conducted using the interview protocol in Appendix E. The questions for these interviews focused on using improvement processes and teacher support within and across classrooms. Semistructured interviews of teachers from across the two schools were conducted using the interview protocol in Appendix F. Questions for the interviews centered on using improvement tools and the collaborative processes within and among classrooms and schools across the district. Each interview lasted between 50 and 60 minutes. Each interview was video recorded using Zoom. Interviews were conducted on Zoom and occurred in the spring of the year following the beginning of the COVID-19 pandemic. The recorded interviews were transcribed using Otter.ai. In addition, I reviewed and edited each transcript by listening to the interview again and making edits as needed. My interviews consisted of a combination of descriptive questions (e.g., "What

are common challenges that teachers or teacher teams encounter when engaging in school improvement planning?") and more analytic questions (e.g., "How has your approach to school improvement evolved over the course of your principalship?").

Focus Groups

I conducted two semistructured focus groups, one with teachers and one with principals. Each focus group interview averaged 55 minutes in length. The focus group interviews were video recorded using Zoom and transcribed using Otter.ai. I reviewed and edited each transcript by listening to the interview again. The questions for focus groups consisted of questions about networking within and across schools and targeted the areas of determining and developing a problem of practice, collaboration, and the use of improvement science methods. My focus group questions included both descriptive questions (e.g., "How do you use improvement tools to understand problems in your practice?") and more analytic queries (e.g., "What effect did collaborating across teams have on your practice?").

Observations

I previously conducted observations as part of my role in the university partnership. Observations occurred monthly during the first year and much of the second year of the NIC. The observations were halted due to the start of the COVID-19 pandemic and the shutdown of in-person learning. The observations centered on the support of teachers during their NIC PLC work focused on improvement processes, that is, RCA and PDSA cycles. I took thorough notes throughout the observations. I reread and coded each note during my analysis. That coded data was used in conjunction with interview and document data to triangulate findings.

Document Collection

Document collection (see Appendix G) included improvement science tools such as fishbone diagrams, PDSA documents, and PLC or individual teacher documents such as planning documents and data collection based on their implementation of improvement science. The artifacts included emails from principals and teachers participating in the study and emails from the researcher to the outside leader during the development of the NIC. The only emails used specifically addressed improvement science, and the identifying information was removed. All documents were stored electronically in a secured Google folder. All documents were analyzed and coded. Document data were used to triangulate findings with interviews and observations.

Data Analysis

I conducted a thematic analysis of the data (Braun & Clarke, 2006), using the six steps to complete my thematic analysis: "familiarizing [myself] with [my] data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report" (Braun & Clarke, 2006, p. 87; see Figure 2). I used MAXQDA, a qualitative data analysis software package, to support my analysis. First, I transcribed the interview and focus group recordings with the support of Otter.ai. Continuing with Braun and Clarke's (2006) first step, I read and memoed each of the teacher interview transcripts, teacher focus group transcripts, and documents from teachers or teacher PLCs. I also read and memoed the principal interview transcripts, principal focus group transcripts, and observation notes from principal coaching. Second, I began to develop my initial codes and used the theoretical framework of NICs and coherence to inform the development of my coding scheme by utilizing the four distinct characteristics of a NIC (Bryk et al., 2015) and the conditions for coherence (Honig & Hatch, 2004). The codes were based on interview responses, focus groups, and document collections. I

created general codes focusing on key phrases that highlighted participant views of coherence, NICs, and improvement science processes. For instance, one code I used initially when describing the raw data was "exit tickets." This code came directly from the transcript of teacher interviews, documents, and observation summaries. Once I analyzed the data and created general codes, I moved to the third step. I began to systematically assemble coded data into the possible themes that emerged across the data sets. I used the data gathered during general coding to create a narrower focus that provided descriptive information aligned with the theoretical perspective. Using the previous example, I bundled the codes of exit tickets, NWEA data, and state testing into a thematic code, use of data. The code, use of data, aligns with one of the coherence variables in the theoretical framework. Fourth, I reviewed the potential themes for coherence within the coded data sets and across the entire data set, creating a thematic map (Braun & Clarke, 2006). During the fifth step, I identified the "'essence' of what each theme is about (as well as the themes overall) and determin[ed] what aspect of the data each theme capture[d]" and the written analysis for each (Braun & Clarke, 2006, p. 92). Finally, I created a report of my analysis that tells the story of my data both "within and across themes" and makes an argument related to my research questions (Braun & Clarke, 2006, p. 92). Specific examples meant to be the most representative of the information from various interviews, focus groups, and documents were generated in the final manuscript.

Limitations

The present research is limited to a single urban school district and is representative of two classrooms in each of the two schools. In addition, the focus is on two intermediate grade levels, and the study is limited to math instruction. Additional research would need to be conducted to understand how teachers across more than two elementary school grades or in

different content areas perceive NIC development, the use of improvement science processes, and coherence across a larger span of grade levels across a networked improvement community situated in a K-12 setting. The principals worked in elementary schools and had five or fewer years of experience in school leadership. Additional research would need to be conducted to understand how more experienced principals approach teaching and learning in the context of a NIC.

The COVID pandemic did not allow me to conduct observations in classrooms. This limited the study since I was unable to see the PDSA cycles enacted in classrooms. Thus, I completed a retrospective study using artifacts gathered before the pandemic. In addition, the pandemic pushed back the timeline of the study, creating a gap between the implementation of PDSA cycles and interviews. I used documents and observations to triangulate the data and mitigate potentially skewed perspectives.

Chapter 4.

Findings

In spring 2018, a midwestern school district and a large research university partnered to establish a NIC. The purpose of this community was to improve elementary mathematics instruction. The community was affiliated with a national philanthropic organization that spearheaded the use of improvement science as a primary way of working to improve instructional practices in schools.

The NIC was designed to support elementary mathematics teachers in identifying and testing potential change ideas that would contribute to improved classroom instruction. Additionally, the NIC was set up to facilitate conversations across schools and grade-level teams. Thus, the NIC provided teachers with opportunities for learning across schools. Further, the NIC was founded to support teachers in gaining greater clarity regarding the problems they planned to solve.

A central question for the design team related to how the use of improvement science processes within a nascent NIC could be used to improve math instruction and student outcomes. Thus, three questions emerged as central and are addressed in this chapter: (1) How do teachers engaged in an emerging NIC use an RCA to promote a coherent understanding of the problems they are facing in their classrooms, if at all? (2) How do repeated testing cycles through a PDSA contribute to the teacher's understanding of the problems they are facing? (3) In what ways does the shared understanding of a problem of practice derived through the RCA and PDSA better inform the principal's approach to improving teaching and learning?

Uses of Root Cause Analysis Tools

At the beginning of the NIC, the classroom teachers demonstrated limited understanding of their work's (un)common aspects. For example, the teachers focused on their students, classrooms, or schools without considering how problems they saw or experienced were ultimately the same as problems encountered by their peers or other schools. Thus, introducing the RCA allowed classroom teachers to determine the root causes of the problems in their classrooms by reflecting on their instructional practices. However, the teachers initially had difficulty using the RCA tools to guide their reflections. In particular, the teachers struggled to use the fishbone diagram and other protocols to focus on the underlying causes of poor student performance and identify the instructional practices that might or might not explain the existence of this performance.

Initial Challenges with RCA Tools

To begin their work, the NIC focused on training teachers to use RCA tools. The data suggest this training did not fully prepare teachers to use the RCA process to examine their practice and identify a problem that could be addressed through later PDSA cycles. During one interview, a principal described the initial summer training and highlighted the extent to which the initial training did not adequately prepare the NIC participants to utilize RCA as a tool to promote reflection fully:

> We went through some grueling work downtown, working with district leaders on fishbones and driver diagrams, and you know, there were, there a lot of different notions thrown out in terms of where to start. And a lot of it was like a big, I would say, more of a bird's eye view as a school first and where we were with some things.

The principal's perspective reflects the challenging nature of the improvement work that her staff faced when attempting to embrace new tools in their practice. The teachers corroborated this

perspective and offered further insights about the limitations of their initial experience with the RCA process. One teacher reflected during a focus group, "I feel like over the summer when we met and we did the fishbones and the driver diagrams, I had no idea what you were talking about. I left [summer training] still having no idea what you were talking about." Another teacher expanded on this perspective by sharing how the limitations of her understanding influenced her ability to make connections between the RCA process and other steps that she would need to take to address specific improvement challenges in their school:

> I don't know that I could have told you any problems I was going to have in my classroom before I got into my classroom with my kids. So I think like giving examples of what a PDSA is and how that relates to the driver diagram. How that relates to the fishbone diagram would have been much more beneficial than here's your fishbone. Let's find all the problems because we didn't … we didn't know what a good thing was. Well, we didn't know what problems we were looking for, and we didn't have our kids yet, so we didn't know.

As this quote conveys, the teachers who participated in the NIC were not fully aware of the interrelationships between the RCA and iterative change cycles they would introduce later in the process. This suggests that, to effect coherence across classrooms and schools, one cannot assume that introducing the tools alone will stimulate this process.

Improved Use of RCA Tools in Context

The teachers' ability to use improvement tools to support reflection appeared to increase as they used the tools within the context of their classroom, instructional team, or school setting. Strikingly, the teachers often could not describe the RCA tools specifically but modeled behaviors associated with those tools in their practice. For example, one Rolling Hills teacher

shared the need "to find some common overlap of things that we could both kind of dig into together and find that common thread so we would have someone to like bounce ideas off of. ..." This comment illustrates the potential value of a shared problem of practice. A teacher from Main Street School noted similarities in the process for her school: "We started big picture and then just really broke it down into, you know, in our grade level, what things were not going well that we had the ability to think about and change." This comment illustrates the potential value of selecting a problem embedded within the user's local context (i.e., a problem of practice) and, thus, within the user's purview to be able to address it fully. The comments from the participants suggest that they worked to identify common and uncommon issues or challenges in mathematics instruction. In doing so, this reflects the power of the RCA to create coherence among and between classroom teachers, even without explicitly naming the tools.

One of the difficulties associated with the RCA process is that the classroom teachers were often predisposed to focus on classroom issues that did not directly explain the existence of practices contributing to the outcomes they were achieving. Thus, one of the potential benefits of the RCA process was that it forced the classroom teachers to consider the relationship between practices and results, as well as the possible role that variations in practices across classrooms explains. One teacher noted this during an interview:

> Well, it started with that fishbone fishtail fishbone, I think, model and just start to identify all the problems we were seeing. We first started there, and we kind of divided them up on that chart. You know some of the problems are related, and some of them were totally different problems. And then, we talked about the problems we can control versus the problems we can't control and what you can change. If you're complaining about homework ... once they're home, and the parents are reminding them to do their

homework, you can't really change the parent, so it's about what you can do versus like what you can't do, recognizing that.

This quote is noteworthy because it demonstrates the issues being discussed and the influence of the process on shaping teachers' understanding of the problems they could reasonably address in their classrooms. The data indicate that the teachers often entered the process with predisposed assumptions about what caused their mathematics achievement outcomes. However, they became increasingly attuned to the underlying causes through repeated interactions with the tools and the associated behaviors.

Each team had difficulty identifying the problem or issue and, thus, needed to revise their thinking over time. This was often done during school team meetings. During observations of team meetings, my role was both researcher and participant in the NIC because I serve the district in a central office role. For instance, during an observation at Main School, both teachers highlighted small group instruction and differentiation as the key issues they were interested in working on. The idea was a set of strategies that needed to be narrowed into a specific problem of practice. The process of narrowing the teachers' thinking was central to their learning of how the information from the RCA could be used and serves as evidence of the RCA the impact of the process on their thinking about their practice. The fishbone iterations illustrate this impact.

Shifts in the teachers' thinking could be observed in the changes recorded in the fishbone diagrams they produced during the project. The teachers became increasingly clear about the issues they would address versus those communicated to them by either their school principal or the district (see Figures 3–7 in the appendix). Each team's progression was aligned with its context, demonstrating how the team sought to clarify the root cause they would address.

Main School's fishbone iterations had noticeable differences across the various iterations, which suggests that Main School's teachers became increasingly clear about the problem they needed to address. In the first fishbone (see Figure 3), no problem statement or leading causes were listed. In the second fishbone diagram (see Figure 4), the team listed, "Emerging Problem-There is a lack of rigor and alignment to state standards." The third fishbone (see Figure 5) stated, "Less than 50% of students are proficient on the daily exit tickets." Thus, the teachers continued to dive down into the exact problem they were trying to solve. The third fishbone explicitly used data to define a student-centered problem.

The team's skill in identifying root causes also evolved across the fishbones. Initially, the Main Street team noted a variety of root causes they attributed to problems that may or may not have been within their locus of control. For instance, one subcategory listed was "new teams" (see Figure 3). Because the teachers did not configure their teams, they had no control over this potential problem. Additionally, the causes listed may or may not have had root causes aligned specifically to mathematics instruction, for example, "No math point of contact." The reference was unclear and may or may not have affected the teacher's instruction. In the second iteration of the fishbone, the teachers were given a major standardized cause as a scaffold for utilizing the tool. The second fishbone demonstrates that the teachers at Main School increased their focus on subcategories in their locus of control. The Main School participants narrowed down their understanding of the problem. During an observation, the team identified a focus of "scaffolding and differentiation." This markedly differed from their previous understanding that focused on a "lack of rigor and alignment to state standards."

The scaffold of providing major causes may have supported a way to view potential root causes. However, it could also have impeded teachers' ability to capture what they deemed were

the root causes of their emerging problem. The fishbone diagram created later in the process (see Figure 3) had categories, such as "teacher knowledge of content" and "instruction," that directly aligned with the problem they were trying to solve. This is important because it demonstrates that Main School teachers became clearer about the root causes as they better understood the problem they were trying to solve.

The Main School teachers reflected with members of the district's NIC leadership team on several practices. They determined that small groups often failed to adequately support students with more significant learning needs. Meetings with the Main School teachers offered additional opportunities to observe the process they engaged in to identify an instructional practice on which they could improve. As the observations revealed, their understanding of the problem evolved from one focused on high-level changes to specific classroom practices that could be addressed. First, the teachers noted the various learning needs of individual students and the myriad of ways they attempted to support learning across this spectrum. One teacher recounted during the meeting, "Students are at so many different levels, both above and below." Another teacher noted that the differences in student performance resulted in an "engagement" issue, especially with students below grade level "getting where they need to go." The observations of the teachers at Main School suggest they often engaged students who performed at higher levels to tutor or mentor those who did not understand. The teachers discovered that this practice was not the best to use all the time, further indicating they could not pinpoint the student's learning issue during whole-class instruction. For example, both teachers stated that they used Kagan structures and heterogeneous grouping; however, as they explored this practice, they determined they did not have enough time to get to all the groups. In essence, the problem they were solving was the group assignment and monitoring process.

Because they were not working with their lowest-performing students, the students who could not do the work independently often "hid" because the work looked right. The teachers then discovered through summative assessments that the student did not understand the concept and performed poorly. The teachers noted they used an exit ticket to assess student learning at the end of the lesson, but it was too late to correct the issue immediately because they looked at it after math work was done. Indeed, during an interview, one teacher described it this way, "We really just jotted down a bunch of ideas. That's how we started. And then we tried to choose one thing that we could really focus on … we realized that we were not pulling small groups based on data." This demonstrates how one teacher consolidated her thinking about the process throughout the work. These comments illustrate how the Main Street teachers progressively moved toward an increasingly clear understanding of the problem they were attempting to address.

Given their increasing focus on small group instruction as the primary mechanism to improve student learning, the teachers began to tease out why the strategy previously did not produce the desired results. The observational data indicate that the teachers first discussed the produced results after implementing small groups. The notes further reveal that they did not have clarity about the root cause of failed small group implementation. Thus, their previous strategy was to try a variety of ideas. The notes reflect that one teacher indicated they had to "start over" each day because, even if students persevered one day, they might have the same issue the next day. One strategy another teacher stated she used to address a perceived issue was to say, "I'm trying to trick you or challenge you on this one" to motivate the student. She indicated that students typically liked it better when it was a "game" for them, and the students were excited when they saw success. The observational data further reflect that she believed the students may

have lacked confidence or had not been "good at math" in the past. In fact, her colleague stated during a focus group that the students had previously commented during class, such as, "We hate math. We don't like math." She shared that math was scheduled for the last two periods of the day, and the students perceived small groups as "punitive." The observation data and emails between district directors and external partners indicated that the teacher posed the possibility of changing the schedule but finally recognized that this was likely not the main issue. Clearly, this team was grappling with the various instructional practices they had learned and the barriers they faced, given the complexity of teaching and learning in their context. In the end, the team chose to focus on the issue of "scaffolding and differentiation given the levels of all students," which was one of the root causes listed on their fishbone diagram. These comments demonstrate how Main School teachers continued to grapple with and clarify the root cause of the problem they wanted to address.

Another teacher joined the Main Street team during the second year of implementation. Her responses during her interview demonstrated that, although she understood the small group process that was implemented, it was unclear that she understood the RCA process to clarify problems in her context. For instance, when asked what process she used to identify problems in her classroom, she stated, "I do during my lesson a lot of walking around and observing." This illustrates a specific focus on troubleshooting immediate problems but a lack of understanding of the improvement science processes. It further highlights that a new NIC member may need more explicit learning about these processes.

Rolling Hills faced similar issues when utilizing the fishbone diagram. Their team's initial fishbone diagram also did not give a specific problem to solve (see Figure 6). In the second iteration, the teachers focused on one particular problem, "Structure learning

opportunities and differentiate for a variety of learners" (see Figure 7). They, too, listed some subcauses outside of their locus of control. For instance, their initial fishbone listed pressure from state testing/accountability as a root cause, as well as "how I am judge[d]" (see Figure 6). Like Main School, the teachers at Rolling Hills were also given a major standardized cause as a scaffold to utilize the tool in the second iteration. Using those causes, their team considered subcauses more aligned with the problem statement. For example, the Rolling Hills team wrote, "Breaking down standards to different DOKs and moving all kids forward (small groups)," as well as "providing GOOD differentiated work for all kids, especially when teacher needs to pull a small group" (see Figure 6). Both examples from Rolling Hills demonstrate the teachers' shift to causes that could align with potential change ideas and away from those out of their control.

Rolling Hills followed a similar process of reflecting with district NIC leaders, tossing out ideas, and narrowing them down to a specific problem. The teachers ultimately worked toward a clearer understanding of the problem they would address, but this process took time and some trial and error. However, unlike the teachers at Main School, those at Rolling Hills did not initially specify a problem on their fishbone that could guide their work as part of the NIC. At first, their understanding of the problem was too general. Observing Rolling Hills team meetings provided insights into their process. Early observations of this team suggest that the teachers spent a considerable amount of time talking around the issue rather than stopping to consider the root causes. For example, the teachers argued that time was an issue. The data suggest that, in one meeting, as many as 25 minutes of a 38-minute conversation revolved around getting the teachers to focus on the root causes of the problems they were analyzing. Further, as a district administrator, I spent time getting teachers to stop, listen, think, and analyze what was happening rather than give every possible idea they would like to see happen. The observations showed that

the teachers often spent their planning time generating ideas to solve problems they did not clearly understand. During an interview, one teacher acknowledged the challenge of focusing on the RCA:

> Well, that was hard for me at first because I wanted to change everything at once. I just had to first like go back to, like, keep going back to the root causes of the problem, like that fishtail chart that we used about, like going back–what was really the problem.

During an observation, both teachers finally indicated their current practice was mainly whole-group instruction, followed by circulating from student to student, asking questions, and prompting students. Additionally, they noted that the students were not "engaged" or frequently asked questions. Furthermore, the teachers stated that the students struggled to work independently of teachers and often gave up or wanted repeated feedback to lead them to the correct answer. Thus, the team concluded that "students are unable to work independent of the teacher and struggle productively." In addition, the teachers acknowledged that they lacked the knowledge to support students in productive struggle. High-achieving students were thought to want excessive support, leaving teachers little time to focus on differentiation for all learners. By considering classroom issues and their practice, the problem at Rolling Hills came to be defined as "Structure learning opportunities and differentiate for a variety of learners." Rolling Hills teachers spent the necessary time deepening their understanding of the problem and were able to analyze the root causes of their problem. Thus, the problem they were focused on solving was a system to assign and instruct groups based on academic needs.

Ultimately, the classroom teachers' engagement with the RCA tools increasingly facilitated reflection about their practice and promoted the ability to discuss issues found within their approach in similar ways. The RCA positioned the classroom teachers with an

understanding of the problems they could reasonably address in their classrooms. Still, it did not identify how they would introduce changes to shift their instruction. Thus, it was not until they began to engage in PDSA cycles that they identified focused instructional changes that responded to the problems they found. The PDSA cycle extended this ability by promoting teachers' willingness to adopt new practices that responded to these commonly held understandings. It allowed the teachers to discuss the impact of the changes in their practice more deeply. The following section focuses on how the PDSA contributed to the teachers' understanding of the problem and their ability to address the problems within their classrooms positively. Drawing from their knowledge of the problems, the teachers across schools reflected on their instructional practices to determine which methods could contribute to the outcomes they observed with their students.

Use of Plan-Do-Study-Act Cycles to Facilitate Focused Instructional Changes

After considerable debate and discussion, the teachers from both schools ultimately selected small group instruction as the change idea they would test and potentially implement. The teachers refined their problem of practice after reflecting and clarifying their thinking. Each school team used its refined problem of practice of small group instruction as the starting point for its PDSA. However, each school used a different approach to the problem. Teachers' use of data was often challenging but essential in driving their ability to address the problems in their respective classrooms positively.

Main School Team: Shared Approach to the PDSA

The example from Main School illustrates a shared approach to defining the problem and determining the change idea. This approach more closely aligns with the goals of a NIC. Main School teachers used a PDSA tracker to focus their PDSA cycle. The PDSA tracker stated their

refined problem was “Students are not being pulled for math groups based on data.” The problem Main School teachers initially defined illustrates that they used small group instruction. Nevertheless, they were not strategic when determining which students would be in a group before using the PDSA process. Indeed, during an interview, one Main School teacher shared the following:

> Rather than just grabbing a few kids and saying, “You go with the instructionalist,” we needed to figure out what data we even needed to gather to figure out who went where. So we had to come up with—figure out—where the issue is. Like, what, how, what kind of groups do we want? Do we want groups based on overall, like, in math, these kids are really high? These are medium, and these are low? Or do we really want to get down to the nitty-gritty? And we decided that we need to look at each step and each standard and really focus in on the lesson of that day.

She first illuminated their previous process. Further, her comment demonstrates that she and her colleagues were grappling with their understanding of the problem and how to determine their plan. In addition, the teacher noted that the team needed to look at the correct data type at the outset to ensure that they better understood the problem and could design an aligned change idea. Thus, the teachers developed their understanding of the problem first through reflection.

During a series of observations, the teachers at Main School grappled with their current implementation of small groups. After analyzing current practices, the team realized that small groups must be implemented systematically. The observational data reflect that Main School teachers acknowledged they were “not targeted; never know what we are doing; small groups are not implemented with fidelity.” This quote reflects the teacher’s understanding of the problem as a systems issue. During another observation, the teachers were asked what the change idea was.

The teachers stated, “Implementing targeted small groups.” They further noted using the previous day’s exit tickets to determine the students they would work with. Thus, the teachers were using the exit tickets to gain clarity on the problems students encountered and how they used their change idea of small groups to address those needs.

Rolling Hills Team: Use of Individual Classroom Context in the PDSA

Meetings with Rolling Hills teachers presented opportunities to better understand their approaches to defining the problem they were attempting to solve. Specifically, each teacher from Rolling Hills initially grappled with individual classroom instruction and root causes. Both teachers determined that small group instruction would be the lever to increase student outcomes. However, the teachers had different entry points for trying out this change idea. Initially, each teacher used their unique context to focus on the change idea. Individual practice and classroom dynamics determined each teacher’s approach because they taught different grades and did not have a common plan time built into their daily schedule during the first year of the NIC.

One Rolling Hills teacher lacked clarity regarding what to focus on and sifted through different ideas. As observed during team meetings, this teacher had multiple changes she wanted to make but did not clearly understand what she intended to do. Her understanding of the problem was not clear enough to define a course of action. Thus, she was unable to identify a clear change idea. She finally decided she should gather baseline data to determine her problem of practice. She utilized that data to determine her focus and created a plan to implement small groups.

On the other hand, the other Rolling Hills teacher could articulate her problem of practice, which focused on using small group instruction. During one meeting observation, the teacher shared, “I am not consistently pulling skills-based small groups.” She confirmed this

later during an interview, “My problem was being able to get to small groups.” She indicated that, when she attempted to implement the strategy, “It would always fail, fail, fail.” She believed, “I can’t do it. I can’t do small groups.” She also indicated that she abandoned the small group strategy and only taught using whole-group instruction. This time, she determined the root cause for implementation and addressed it in practice. Both teachers at Rolling Hills decided to use the same change idea. However, their understanding of their unique problems of practice impacted where they began.

Ultimately, the teachers from both schools had varied ways of determining the problem of practice. The teachers used an individual or team approach based on the existing systems and their classroom or school context. This illustrates that a school’s structure can potentially affect how teachers initially understand and seek to address a problem of practice. Still, all teachers on both teams eventually landed on small group instruction as the systemic change idea to implement. Thus, both schools’ teachers began to cohere around a single change idea.

Data Use and Challenges in the PDSA Cycle

Both schools utilized a variety of data types to determine how to implement their change idea and assess how their small group change idea was working. The data gathered evolved and moved from implementation data to academic impact data. In one instance, data were collected to determine readiness to implement small group instruction. The teachers believed the data were vital to the process; however, the teachers indicated that data gathering was a significant challenge.

The teachers at Main School began the process by collecting implementation data but later decided they needed impact data. The observations indicated that initial data were used to focus on the implementation of the groups and if small groups were consistently meeting. One

artifact—the team's first PDSA on a page—confirmed that teachers were indeed tracking implementation data by noting "the groups, number of groups, [and] students who met" (see Figure 8). They also reported that "groups met 80% of time." Once teachers knew the small groups were meeting, they turned to impact data to measure the success of small group instruction. During an observation, the Main School teachers decided to add names to their Google doc to track the progress of the students who participated in the small group and see if the change idea was impacting students' performance on the summative assessment. Their notes on the PDSA on a page indicate that the small group work did not initially move students to mastery on a summative assessment. Thus, the Main Street teachers adapted their PDSA and attempted to gather data closer to the change idea to determine the impact. They utilized exit ticket data to assess learning. During an interview, one teacher shared the following:

> So we would look at each kiddo's exit ticket at the end of the day; we would take the entire fifth-grade class and check yes, they got it on this first try, or they didn't. And those kids that didn't, we would break them into different small groups with different teachers for the next day. And after that small group and that second exit ticket, we would go back in that same data and look to see which kiddos still needed an extension, like more intensive instruction maybe.

By the end of the first year, the Main School teachers implemented a robust data analysis system to impact student learning. Their use of data allowed them to continue to refine and bundle PDSAs to improve student outcomes.

Each teacher at Rolling Hills used data within their particular context to prepare for small groups. The data each teacher gathered demonstrated how they approached their initial problem differently. The data iterations show the teachers' progressions of thinking throughout

implementation. One Rolling Hills teacher initially collected baseline data. That data would be used to help her maintain focus on the best change idea. Initially, she needed to clarify the problem. The first change idea she identified was "creating mini lessons that are only 15–20 minutes. Seeking to ensure all the work can happen in 60 minutes." However, the artifact she provided for her usual schedule already included a 15–20-minute mini-lesson. During team meetings, this teacher had multiple changes she wanted to make but did not have a clear picture of what she intended to do or data to support a specific change. Her understanding of the problem was not clear enough to define a course of action. Thus, she was unable to identify a clear change idea. She finally decided to gather baseline data for how many minutes she spent in each lesson component. She labeled the lesson components "problem-solving, mini-lesson, guided practice, independent work time." Later, she provided an artifact of her minutes. Within two weeks of gathering and analyzing her data, she clarified her problem of practice. Specifically, her written plan stated, "I spend too much time on whole group instruction." Thus, she gained clarity after analyzing practical data in her context and could articulate the problem she wanted to address.

After identifying her problem of practice, she moved to implement her change idea of small groups. During a meeting, she shared her initial data of recorded dates, that is, the number of days per week she met with a small group. The Google document she created showed how she refined her data collection, noting whether she met with a small group and the number of students in the group. This step supported the teacher in determining if small group instruction was what she needed to focus on in her classroom. In this way, she used data to progress through her PDSA cycle.

The other Rolling Hills teacher used data to determine if the conditions for implementation were optimal. She indicated that she always struggled to implement small group instruction during her tenure at Rolling Hills. She hypothesized that she did not have the right classroom conditions to address the problem and collected data to confirm her hypothesis. She shared the following during an interview:

> My issue was being interrupted during small groups. So I first just did a tally chart of how many times I was interrupted to see if that was really my problem or not. I mean, I just did a simple paper/pencil tally chart. And from there, I identified there was a lot of interruptions.

Thus, data collection analysis allowed her to identify the initial problem accurately. Although seemingly simple to identify the problem, data gathering created a concrete, brief means to assess the root cause of the lack of implementation accurately. This led to the creation of a PDSA cycle aligned with the root cause.

Her first PDSA cycle was to set up the necessary conditions. During an observation of the team, she identified the root cause as student interruptions because they did not know what to do if they were "stuck" or finished. Her two-pronged plan was to create a menu with strategies for students who were stuck and a set of choice activities for early finishers. The artifacts verify that she did indeed develop both strategy sheets for students. During an interview, she shared how she used an early finisher choice list to reduce interruptions so that she could enact the small group strategy. Hence, both Rolling Hills teachers first utilized data in their particular context when implementing small groups.

Once the Rolling Hills teachers analyzed their initial data and set classroom conditions, they moved from implementation data to impact data. Both teachers began using exit tickets to

determine the impact of the small group instruction on student learning. One teacher noted the following:

> And I was studying that data. Of the kids who were in there and seeing, like, did they grow? Did they not? So analyzing that data to see did your strategy work or did it not. That's the key thing is collecting that data that truly, like, represents what you're trying to do.

She recognized the importance of the data to determine how her change idea was working. However, it was unclear to the Rolling Hills teachers how to best represent their data to show the impact of small group instruction on student learning. One teacher had shared that she previously abandoned a PDSA because she "couldn't manage" two different systems. At a separate meeting, she stated, "Honestly, the data collection is my weak area. I feel it weighs me down." These statements represent the complexity and concerns about utilizing and managing relevant data within the classroom setting in conjunction with other responsibilities.

The other Rolling Hills teacher had data but struggled to display it in a meaningful way that supported determining how the PDSA was working. In my district role, I worked with the team and modeled a different approach to data display for her. After the process had been modeled, she had a bar graph that showed how the data changed for a single day. Each topic was represented with two bars of data. The first bar for the day represented how students performed on the exit ticket after whole-group instruction. The second bar for the day represented how the students performed on the exit ticket immediately after the small group met. The data set concisely showed whether there was progress for each day. The teachers wanted to be able to analyze data but struggled to create easily readable data sets.

During an interview, this teacher explained how sharing the data she collected during a cross-school NIC meeting impacted her practice and the practice of others:

> One, it held me accountable actually to collect my data consistently. Not just for myself, but I knew that, you know, I had those other people that were curious, is your strategy working? Because a lot of us were interested in each other's ideas. We're like—Oh. That's a great idea. Oh, that's a great idea. And we could see, oh, was that working for them? How can I then, if you see that it's successfully working for them, you know, it's something that you could do because when we create these PDSAs, we create a step-by-step process of what we're doing to implement these in our classrooms. So being able to see other people's data and know that it's working or it's not working.

Her response demonstrates how data can hold teachers accountable to themselves and other NIC members. Additionally, the response indicates how PDSA impact data can create opportunities for other NIC members to understand the effects of a change idea. Thus, the data were sometimes complex to gather or display, but it was essential to the process. Further, modeling a concise, manageable data set supported the teacher in using data to determine how the intervention worked.

Building Coherence Across Classrooms

What became visible as the teachers worked through the process was that their understanding of instruction and the problems in their classrooms tended to become more similar than different, thus spurring them to act in ways that suggest a higher degree of coherence across classrooms. The teachers at Rolling Hills used exit tickets, "quick checks," to determine which groups students should attend each day. However, they used different processes until one teacher

shared her approach with the other. Indeed, her colleague at Rolling Hills noted the impact of sharing both data and strategy during an interview:

> I remember [my colleague] and I, at one point, and we'd really kind of tried to take on some they're almost the same—similar—things. But having that conversation … My takeaway—let me see if I can phrase this all right—was hearing [my colleague] walk through that before she gave the three-question quick check she was going over like when you get—[be]cause she was doing it digitally—so when you get your results, if you're a zero or one, here's what you're doing next. If you're a two, here's what you're doing that. If you're three, here's what you're doing next. So it was a smoother flow from quick check into that next process. Whereas for me, it wasn't. I was waiting for all the quick check results to come in and then giving that guidance and direction. And so, to hear her talk about how smooth it was running, I was like, "Oh, that's brilliant." I need to change when I give those next steps. And it just—it did. It just made everything move smoother … And moving into the next step much smoother that for me was such an aha, to have someone else in the trenches with me going, "Oh, well, I do that before that." And it was like, oh, okay, then I can try that, too.

This teacher articulated exactly how she adapted her process in her classroom by taking up an adjustment her colleague found successful. Specifically, she determined that providing instructions before giving the quick check improved transitions to small groups. This demonstrates how the PDSA process contributed to coherence within and across classrooms at Rolling Hills. Evidence from each test provided an opportunity for refinement and adjustment across classrooms. This brought the teachers closer in their instructional practices while creating

a shared understanding of the practices they sought to create. Indeed, this is corroborated by a Main Street teacher in a separate interview when she shared the following:

> I think our most powerful conversations were after because we did our exit tickets at the end of our math period. And then, we would come together as a team at the end of the day and look at them and determine, you know, what mistakes are being made. What do we need to fix? And a lot of times, we had one classroom that just really outperformed another, and so it almost brought in more conversations of how are you—What did you do differently? What did you say differently? How did you teach this differently—that your class really got it when mine didn't? And it was really cool because we're all in such different places as math teachers, just because of the nature of my team. You know, we had a first-year fifth-grade teacher, we had a first-year math teacher, and then [instructionalist], and I had been teaching fifth-grade math for a long time. And there were times when the other classes outperformed mine. And so, we were able to really be humble and say, you know, what did you do differently because I want my class to get what your class did. And so, it brought a lot of unity in our team, I think, because everybody was willing to have those conversations.

In this instance, the focus was on instructional processes that could be used to improve student learning. The quote provides evidence that the Main School teachers sought to strengthen their instructional practice through questioning and explaining across the team. This teacher's comments reflect a collective desire to improve and the desire for all team members to contribute and learn from one another. The reflections from both teachers demonstrate a consistent move toward a more coherent understanding of the implementation and instructional processes to address better the problems each one is trying to solve.

In summary, the analysis indicates that the teachers at both schools became more precise about the problems they were trying to solve by using improvement science tools. Specifically, the RCA fishbone showed the progression of teachers' thinking and how they clarified both root causes and the problem to be solved. The use of data supported teachers in clarifying problems of practice and implementing PDSA cycles. The PDSA cycles provided a template for thinking about and implementing change ideas to address their problem of practice. The progression of PDSAs supported teachers in refining their approach and becoming more coherent across classrooms.

Principals Focused Support "At the Margins" of the Improvement Process to Assist but Not Manage the Improvement Work

Before the launch of the NIC, the principals took a more central role in problem-solving instead of shared problem-solving with teachers. For instance, one principal acknowledged the following during an interview:

> So I had never really done [school improvement planning] before so much that we all had ownership in it. You know, it was kind of like, here's the school improvement plan. "Here's what's been done to you" kind of thing, and now, you're gonna do it.

This quote suggests that the principal provided a plan on what problems needed to be addressed and how they would be solved in their school. During a focus group, a teacher confirmed this perspective when she stated, "… so often there are things that come down from district level or even from building administration, and there's things that we don't have a choice in or certain aspects of our curriculum that we can't change." Thus, the teachers did not have as much ownership of the work. However, the principals shifted from telling teachers how to solve their problems to allowing teachers to be at the heart of their problem-solving through teacher use of

the RCA process and PDSA cycles. One Main Street teacher said it this way during a focus group, "[The RCA and PDSA processes] gave us the opportunity to own a change in our classroom and say, 'This is where we think that we can improve. This is how we can better help our students and really bring that onto ourselves.'" The comment denotes that the teacher saw a shift in principal practice that allowed her to have ownership of problem-solving.

The principals adjusted their practice to avoid disrupting the inquiry process, and they altered both the structure and techniques they used for providing support. Each principal had her understanding of the problem from the RCA and PDSA processes, and each aligned her approach to the problem teachers were trying to solve. One finding suggests that the structure of principal huddles provided flexibility to support the iterative cycles that were driven by teacher decisions throughout the inquiry process. Furthermore, the perspectives of both principals and teachers regarding the change in support style illuminate a shift in the relationship between principals and teachers as they moved to a more collaborative stance. The analysis indicates that principals' support for teachers entailed using question stems to craft questions that allowed teachers to think about their PDSA cycle and adjust their change idea throughout the process. Finally, the principals focused on the data of the PDSA cycle when supporting their teachers.

Principal's Understanding of the Problem

Each principal's understanding of the problem their teachers were trying to solve was essential for how the principals focused their support. The principals shared their understanding of the initial problem during the principal focus group. The Main School principal described the following:

> Ultimately, as we kept drilling down—and there were the six, the six questions you had for us—The team came to consensus that they weren't meeting with groups consistently, with any fidelity, with any integrity. So that's kind of where they started.

According to an early iteration of their fishbone diagram, Main School noted that one root cause was a lack of "scaffolding and differentiation given the levels of all students." The principal referenced "the six questions" from a protocol that teams used early in the RCA process. The principal's response demonstrates that her understanding of the problem was more focused on the lack of strategy based on the problem the team had previously identified. However, when specifically asked about the problem they were trying to solve through implementing small groups, the principal responded, "They were trying to meet with students to continue to move them because they were performing at such low levels in terms of achievement with math skills." This suggests that the principal understood the problem but focused more on the strategy, illustrating the principal's focus on student achievement data as the performance measure. The Rolling Hills principal described the problem as follows:

> So for both of them, really, they were not seeing progress, like they wanted to see, you know, within their classes and in terms of kids growing, whether that's the high-ability students or our special education students. So they, you know, obviously had to dig in ... found concerns around just that—that growth, whatever it looked like for each kid.

According to one iteration of their fishbone diagram, Rolling Hills School noted that their problem statement was that they were not "structur[ing] learning opportunities and differentiat[ing] for a variety of learners." This principal's response suggests that her understanding of the problem centered around the problem statement. She specifically mentioned a lack of student progress and growth for two populations: high ability and special education.

Furthermore, the statement illustrates that she also connected the issue to student achievement data when describing the problem, here by emphasizing that they were "not seeing progress." The principal went on to articulate questions the team needed to respond to and a structure one teacher needed to implement. Then, the principal noted, "After that was established, then we could begin to look at the cycle and what we were going to do to attack that data." Thus, the principal sought to consistently focus on the data related to the inquiry cycle and assess its impact on student achievement. Both administrators used their knowledge of the problem to target their support.

The Principal Huddle

The principals used a "principal huddle" to support teachers in their schools, and they described a huddle as a quick "check-in" or "walkthrough" that allowed them to ask questions and respond to teacher questions related to the PDSA. The principals used a variety of structures to implement the huddle and adapted their approaches based on the needs of their teachers. Essentially, both principals used the principal huddle to varying degrees and in a nimble fashion to support teachers. The NIC members from Main School taught the same grade and, thus, had designated PLC time for part of their work. The Main School principal reported that she conducted most huddles during PLC time. In addition, the Main School principal utilized other strategies for huddles. During an interview, she described other huddle opportunities as "touch[ing] base with them as frequently as possible … not necessarily in person, but I try to be readily available at all times. So weekends, at night, they would reach out, brainstorm ... and that still happens." This suggests that the principals' willingness to be available for support when teachers were planning during and beyond school hours. In addition, it indicates that the support was centered around immediate teacher needs. Further, the principal noted the following:

> The huddle provides so much insight. … You can confer with [teachers], go deep enough to almost like release them to then continue whatever work they're on. So I hope that is what [NIC teachers] were able to take away from it. We were able to huddle. They were able to design what they were opting to do, how they were going to track it, and how they were going to share it. And ultimately through that process, they tweaked on their own and evolved and grew on their own.

This suggests that the principal found value in using this structure and better understood the problem by focusing on the PDSA cycle when speaking with teachers. Her comments also emphasize her desire for teachers' perspectives of the huddle process to align with her use of it. Additionally, the principal's statement suggests that the teachers were the ultimate decision-makers throughout the PDSA process. During a focus group, one teacher corroborated this when she stated the following:

> And I think for us, it gave us the ownership of changing things in our classroom. You know, so often there are things that come down from district level or even from building administration, and there's things that we don't have a choice in or certain aspects of our curriculum that we can't change. And this gave us the opportunity to, to own a change in our classroom.

Her comment suggests that a shift in structure occurred. The transition from leader-directed change empowered her team to make crucial decisions to address the problem they were trying to solve.

The Rolling Hills principal faced a different challenge because her teachers did not have a designated collaborative time during the day. Thus, the structures varied in this school's context. During an interview, the principal noted the following:

> It really depended for the particular day, or I guess, even the particular what we were trying to do … Sometimes, it would just be me sending an email to them. Because that was just the time we had … Sometimes, it was just me being in the classroom when they might have been implementing some things and them popping over to share, "Hey, I'm trying this"… it was just quicker and easier. And it didn't feel like we had to draw out, like, all these questions and ask a million questions or meet in a PLC because maybe they didn't need that. I mean, maybe they were still just in the process of doing some things. And they just needed to hear from me, you know, and ask a couple questions: "Where you at? What do ... you know, hey, did you, did you get any data collected the last couple days? What's it look like?" You know, just some simple, also kind of just encouraging um so that they wouldn't get defeated … in the process as well. So, sometimes, I felt like more of a cheerleader in that huddle.

As this quote conveys, the principal utilized a variety of structures based on the support's purpose, timing, and availability. Furthermore, she considered the needs of teachers when offering support that was better aligned in the moment. The principal's response acknowledges teachers' challenges when implementing a change idea and how just-in-time support through various structures addressed the immediate need. It also implies that the principal was willing to wear multiple hats, that is, listener, questioner, cheerleader, and so forth, when supporting teachers in the inquiry process. During an interview, one teacher confirmed this practice and even noted that the practice expanded beyond principal support to utilizing this strategy with her peer.

> It would be a huddle with just the principal, or we were all three [NIC members] huddled together. And like, just it could be a short 10–15 minute thing where we talked. I know,

one time, me and the teacher from another grade—we luckily had the same lunch—we huddled real quick that day to talk about [the PDSA cycle] and how it was going.

This indicates the value teachers found in this support strategy and how they used the huddle structure during the PDSA process. Each principal's ability to be nimble suggests that each one had to anticipate and support a variety of teacher needs depending on where they were in the PDSA process. Additionally, it indicates that the principals' roles shifted from telling teachers what and how to change to supporting teachers' decision-making throughout the process.

Principal Use of Question Stems

Using a PDSA huddle to support teachers required a different approach to problem-solving. The new shift in the principal's role was characterized by questioning strategies to elicit teachers' thinking regarding their practice problem and how they would solve it. Thus, the principals were provided with question stems aligned to the PDSA process as a tool they could utilize in their changing roles (Appendix, Table 2)[1]. During the focus group, one principal explained that "those question stems really guided them, like, to their solutions or their findings or their answers." The other principal added, "It also provided them with some reflection time as well." The analysis indicates that the questioning strategies supported a shift in teacher practice and provided opportunities for teacher reflection throughout the PDSA process. Thus, it allowed the teachers to be at the center of problem-solving for their respective classrooms.

Notably, the questioning process used to coach within the PDSA cycle allowed the principals to shift roles from more of a directive style to ancillary support. During the focus group, the Rolling Hills principal shared, "I feel like my approach changed as more as a listener

[1]Question stems tool was developed collaboratively in the district, whose name has been withheld.

and then would more be a teammate. … I felt like, even though I was asking the questions, I became more of a teammate than having all the answers for them." Thus, principals were able to adapt their processes to support teachers better. In addition, this provided greater empowerment to their teachers to solve the issues they face. In an interview, the Main Street principal stated the following:

> That's where some of those question stems have come into play when we're hitting brick walls with change reverting to those so that they're hopefully that's somewhat opening their eyes instead of me getting fixated on what I think needs to be happening and needs to happen now. Sometimes, I have to take a step back and give a little more process time for people so that they can kind of do a little discovery on their own.

This suggests that the question stems were useful in propelling teachers forward. It also indicates that the stems were helpful for the principal to reduce the amount of directing and increase teachers' opportunities for decision-making.

Principal Strategies Focused on PDSA Data

The huddle structure and questioning stems provided principals with a way to maintain a focus on data and support their teachers. The analysis from the focus group affirmed that both the principals attended to PDSA data during huddles. During the focus group, the Rolling Hills principal noted that she focused on data early on in huddles with the teachers:

> In the beginning, because they were a little bit in separate places and their data looked a little bit different, so I would do some huddles with them individually—just you know, check-ins more than anything. Like what's, you know, what's your data sharing with you now? You know, what next steps do you feel like you need to take? And just really trying to, I think the biggest part for me was trying to keep both of my people grounded in the

> data, and not in the feelings of it, you know, like, not in the moments great, which are great to have anecdotal notes, but we can't live there if we're not seeing progress, or lack thereof, in data. So just making sure that they took the time to log that.

This suggests that the Rolling Hills principal consistently used question stems and the huddle method to keep the NIC teachers focused on the data of the PDSA cycle. Being "grounded in the data and not in the feelings of it" emphasizes that the teachers may have focused on their feelings while implementing the determined strategy. However, the principal recognized the importance of what the data revealed about students' academic improvement. Thus, the principal used the huddle structure and question stems to maintain that focus.

During the focus group, the Main School principal noted the difference between the huddle during the NIC PLC and other PLCs. She specifically mentioned the focus on data:

> Where with the huddle, we were strictly focusing on what, you know, what was happening within those groupings and the data. … Because I would, I mean, I asked for data in other PLCs, but this … with this cycle, they were so focused on it, like that hyper-focus, so they have so much [data]. And they were pushed to have it provided and speak to it. And then also problem-solve around that data, where sometimes within a PLC so much time is spent, like [Rolling Hills Principal] said, asking questions, or trying to plan and pull [lesson resources].

According to the principal, their experiences with PLCs typically involved trying to plan or determine which resources to use. This quote demonstrates that the huddle focused solely on the PDSA cycle and the data's meaning. In addition, it suggests that the huddle was the vehicle to assess the data gathered during strategy implementation and determine how to proceed.

In summary, the analysis indicates that principals used their understanding of the problem to align their support for teachers. The huddle and question stems (Table 2) provided a structure and support for principals as they shifted their practice from a directive stance to a more collaborative one. Further, the analysis demonstrates that principals focused on the data of the PDSA cycle to understand how the strategy was working and support focused work to solve the problem.

CHAPTER 5.

Discussion and Implications

The purpose of the present qualitative case study was to understand how the development of a NIC and its related emphasis on RCA and PDSA cycles increased coherence in instructional practices across classrooms and schools in an urban setting. The analysis indicates that teachers initially struggled to use the fishbone diagram to analyze the root cause of poor student performance or the problems of practice that could explain that performance. This finding aligns with previous research that the collective understanding of problems of practice can vary based on experiences (Horn & Little, 2010). Furthermore, the analysis indicated that the teachers' use of the RCA process, with support, improved over time and facilitated teachers' reflections on their practice, promoting their ability to discuss problems of practice in similar ways. This finding aligns with previous research that NIC members need support to engage in the scientific inquiry process (Russell et al., 2017). The analysis indicates that the progression of the PDSA cycles highlighted the similarities in teachers' problems of practice leading to more coherent approaches across classrooms. This finding aligns with the research suggesting that improvements should be spread across settings (e.g., classrooms) (Bryk et al., 2015; LeMahieu, 2017). The analysis indicates that using data supported teachers in implementing PDSA cycles but was challenging to gather and organize. Tichnor-Wagner et al. (2017) found that capacity was an issue with data collection. The analysis of the current study suggests that tools and protocols provided to principals enhanced their coaching of teachers throughout the process. Rigby et al. (2017) have argued that principals need resources and support to improve instructional quality. In sum, the findings above demonstrate that the teachers gained a better

understanding of a problem of practice and more coherent way to address it through leader support and the use of improvement science tools.

Use of Root Cause Analysis to Build Shared Understanding

The analysis indicates that using improvement science processes and tools (i.e., RCA, fishbone diagrams) (Bryk et al., 2015) supported the NIC teachers in shifting from a limited to deeper understanding of the commonalities in their problems of practice. Initially, the teachers had various ways to view and address issues in their respective classes. Research confirms that isolated teacher practice impedes progress and leads to variability (Russell et al., 2017). The principals and teachers attended training at the outset of the NIC formation, and the NIC participants indicated that initial training was insufficient to support a clear understanding of using the fishbone diagram. The current classroom context mattered for teachers, who may or may not have initially seen commonalities across classrooms. Teachers' ability to use the tools increased with support and after reflecting on the contexts within their classrooms, teams, or schools. This finding aligns with research suggesting that it takes time to understand how to use improvement science tools (Rohanna, 2022). To gain a more coherent common understanding, stakeholders encounter "enabling conditions" that help support them in their understanding and "constraining conditions," such as the various ways they interpret the problems (Honig & Hatch, 2004, p. 22). NIC members' original understanding of their problems of practice through RCA was constrained because of how the teachers in the current study took up the process. Research indicates that teachers often do not have shared language or processes when collectively addressing a problem of practice (Horn & Little, 2010). Indeed, the analysis indicates that teachers' early ideas varied based on their context and school structures, thus initially limiting coherence. However, the teachers at each school increased their understanding of root causes by

reflecting on and discussing their instructional practices and iterations of the fishbone diagrams. This confirms previous research that reflective dialogue is an essential practice (Bryk et al., 1999) and that reflective practice can deepen one's understanding (Rohanna, 2022). Thus, the teachers began to articulate an understanding of problems they could address in their classrooms.

PDSA Cycles of Improvement to Build Coherence Across Classrooms

In the present study, teachers in a nascent NIC used PDSAs to address student learning issues. Educators use PDSA cycles to create improvements that can be shared across contexts (Bryk et al., 2015; LeMahieu et al., 2017; Russell et al., 2017). Like using the RCA process and tools, how teachers in the present study initially determined how to implement their change idea varied based on their classroom context and school structures. Each school in the NIC approached the PDSA differently. The Main School teachers readily decided on their change idea, implementing small group instruction, and were able to use their context to begin. Tichnor-Wagner et al. (2017) have found that incremental change aligned with previous learning was beneficial in using PDSA cycles. Teachers at Rolling Hills articulated the same change idea: small group instruction. However, each teacher approached the idea differently using their classroom context. Previous researchers have stated that disciplined inquiry requires addressing context and variation across contexts (Bryk et al., 2015; LeMahieu et al., 2017; Russell et al., 2017).

The analysis suggests that teachers in the NIC were concerned about time constraints in PDSA implementation. Time is necessary to build coherence (Honig & Hatch, 2004). It took time and practical use for teachers to expand their understanding of PDSAs. Initially, the teachers spent a great deal of time clarifying their understanding of the problem of practice and determining the change idea to address it. In the current study, data were also a significant time

challenge. The teachers believed data were vital to understand how the PDSA was working but indicated that collecting, organizing, and using the data presented a significant challenge. One of the teachers even abandoned a PDSA because of data collection challenges. This finding is consistent with research that collecting and analyzing data are a teacher capacity issue (Tichnor-Wagner, 2017).

Additionally, the challenges with data are a constraining condition in information management that can impede coherence (Honig & Hatch, 2004). One mitigation strategy in the case study was coaching support from NIC members with data expertise. Previous research suggests that coaching and data support are important tasks of district facilitators to support NIC members (Russell et al., 2017; Thompson et al., 2019). In this instance, the researcher and district facilitator modeled a concise, manageable data set to help teachers see how the change idea impacted student learning daily. Bryk et al. (2010) note that practitioners need real-time data to determine how a process works. The new data displays gave quick information to support learning about how the change idea worked and added to teachers' capacity. Specifically, teachers could view the data and know immediately what proportion of the class had successfully completed the exit ticket. This added to teachers' decision-making capacity by allowing teachers to quickly determine whether they needed to reteach the lesson to the whole class, pull a small group to reteach part of the class, or simply advance to the next lesson. Honig and Hatch (2004) note that a school's capacity to manage and understand data is essential to crafting coherence.

NIC members collaborated in each school and across schools. Van Lare and Brazer (2013) note that teacher interactions can impact their learning. The teachers in the present study discussed specific routines and processes, instructional strategies, and impact data. Indeed, the teacher interviews provided specific information on how the discussions led to similar classroom

practices. This finding also aligns with the essential nature of reflective dialogue (Bryk et al., 1999) and with research that network collaboration with deeper learning can create shared coherence (Fullan, 2016). The findings indicate that, through collaboration and iterative PDSA cycles, the teachers became more precise in their understanding of problems of practice and the instructional moves they used to improve them, thus creating more coherence across classrooms.

Principal Support of Teachers Engaged in the Inquiry Process

Previous literature defines critical elements of principals' roles in a NIC as providing resources such as time and coverage (Rohanna, 2018) and being a HUB liaison (Peurach et al., 2016). This case study expands on the literature to add elements of a principal's roles and practices within a NIC that focuses on elementary school mathematics. Specifically, it provides insights into what worked for elementary school principals when coaching teachers in a math-focused NIC. In this case study, the principals articulated that one of their primary roles before the NIC was a directive stance on school improvement and that their roles shifted to a coaching stance after entering the NIC. A primary finding is that principals' understanding of the problem of practice and the implemented PDSA cycle created a focus for their interactions with teachers. This contributed to more coherent actions and targeted support. Honig and Hatch (2004) state that aligning activities to the goals and strategies implemented in schools is vital in crafting coherence.

In the present study, the principals were taught a flexible coaching structure—the huddle—to address teacher questions and support the implementation of the PDSA cycle. The flexible nature of the approach allowed them to better address the needs of NIC teachers within the constraints of their schedules. Specifically, the principals attended to the context of their building to provide PDSA support to teachers. One principal used structured team time and after-

hours texts or phone calls, while the other used impromptu hallway huddles or quick office visits to support one or both teachers. This aligns with the research that attending to context when providing instructional support is an essential leadership practice (Leithwood, 2020). Additionally, the principals were provided question stems aligned to the PDSA cycle to use during the huddle (Table 2). Researchers have noted that administrators need support in giving relevant feedback to teachers (Lochmiller, 2016) to improve the chances of creating instructional improvement (Rigby et al., 2017). In the present study, both principals utilized the PDSA question stems (Table 2) to enhance their ability to provide focused coaching to their teachers. The principal's use of PDSA question stems (Table 2) within the huddle structure supported teachers in their reflections about their PDSA cycle and how it did or did not create an improvement. This aligns with research on the need to increase the depth of teachers' reflections on their instructional practices (Rohanna, 2022). The strategies that principals enacted provide specific examples of how a principal can support reflective practices in teachers and gain insights into how they do this. Leithwood et al. (2020) note the need for additional research on the practices principals implement, how the practices get executed, and the effects of those practices. The current study contributes to the literature by providing specific practices that leaders could use to support coaching teachers in a NIC to improve instructional practice.

Limitations of the Study

The present research is limited to one urban school district and is representative of two classrooms in each of the two elementary schools. The study is limited to intermediate-grade math instruction. The principals in the study are elementary principals with five or fewer years of experience in school leadership. Additionally, the COVID-19 pandemic restrictions did not allow me to conduct classroom observations. Because of the size of the case study, it is impossible to

generalize the results to other settings. A larger sample size or studies at other grade levels could be used to provide additional insights into the findings. Further, studies of the supports principals with different levels of experience provide teachers in a NIC could also add to our understanding.

Recommendations for Future Research

The present study provides some insights into how teachers in a nascent NIC used improvement science tools to understand better and address problems of practice. It also provides a starting point for understanding how principals can support teachers in this pursuit. There are additional opportunities for further research that would help researchers better understand teachers' and principals' roles and responsibilities in NICs.

1. Additional research is needed to better understand how elementary school math teachers' use of PDSA cycles supports coherent instruction across an entire school or schools.
2. More research is also needed to better understand how the use of improvement science tools by elementary math teachers impacts student learning. It will be helpful to see quantitative measures of improvement in student learning.
3. Further research is needed to find ways to mitigate issues of time constraints in the use of data.
4. Future research should include other approaches to improving teaching and learning in NICs.
5. Additional research is needed to understand how PDSA coaching stems impact teaching and learning in classrooms, within and across schools.
6. More research is needed to clarify how NIC members craft coherence.

From a practical stance, teachers can use scientific inquiry to address problems of practice and make positive changes in their classrooms. Using a coaching stance through flexible structures can help school leaders better support teachers in reflective practice and dialogue with their colleagues. We already know this type of reflection is essential and that these types of techniques could lead teachers to better understand the problems they face and design ways to address them.

A superintendent that is planning to establish a NIC must consider the conditions necessary for inclusion in a NIC and the approach used to form it. A district that selects to establish a NIC should consider a bottom-up approach. Central office leaders could support school leaders in establishing a NIC based on a common problem of practice that schools had already identified. A superintendent that uses this method would mitigate for a school that has a different priority, a new principal that had not yet established a clear understanding of the needs in their school, or other potential impediments to the initial work. Further, this approach provides the opportunity for a more coherent path to a common goal and context that is necessary to conduct a root cause analysis and implement successive PDSA cycles to address the problem. It also allows the superintendent to more strategically deploy central office personnel with the necessary expertise to support the NIC.

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Appendix A

Recruitment Email Message

Dear _____,

I am working on a qualitative research study that seeks to identify how school principals and teachers implement improvement science in an emerging networked improvement community (NIC) focused on elementary mathematics. To complete this study, I am engaging with principals and mathematics teachers within the NIC.

I identified you as a potential participant because of your membership in the NIC. I would like to conduct an interview with you for up to 60 minutes. I may request an additional follow-up conversation with you for further clarification, if needed. In addition, I may ask you to provide copies of artifacts from your teaching or meetings (e.g., lesson plans, assignments, work products, etc.) and/or to allow me to observe your mathematics classes or NIC-related meetings at a time that you select.

I have attached a study information sheet that provides additional information about your rights as a research participant. If you are interested in participating in this study, please let me know and provide a few times that might work for you to complete this interview.

Thank you for your consideration.

Holly Pate
Doctoral Student
Indiana University Bloomington

Appendix B

INDIANA UNIVERSITY INFORMED CONSENT STATEMENT FOR RESEARCH

A Qualitative Study of Principal and Teacher Perspectives on Implementing Improvement Science in a NIC Focused on Elementary Mathematics

IRB Protocol Number:

ABOUT THIS RESEARCH
You are being asked to participate in a research study. Scientists do research to answer important questions, which might help change or improve the way we do things in the future.

This consent form will give you information about the study to help you decide whether you want to participate. Please read this form and ask any questions you have before agreeing to be in the study.

TAKING PART IN THIS STUDY IS VOLUNTARY
You may choose not to take part in the study or may choose to leave the study at any time. Deciding not to participate or deciding to leave the study later will not result in any penalty or loss of benefits to which you are entitled and will not affect your relationship with your school district or school.

WHY IS THIS STUDY BEING DONE?
The purpose of this study is to understand how school principals and teachers work in an emerging networked improvement community (NIC) focused on elementary mathematics. You were selected as a possible participant because of your membership in the NIC. The study is being conducted by Holly Pate, doctoral student at Indiana University Bloomington.

HOW MANY PEOPLE WILL TAKE PART?
If you agree to participate, you will be one of up to eight participants taking part in this study.

WHAT WILL HAPPEN DURING THE STUDY?

If you agree to be in the study, you will do the following things:

- Participate in one semistructured interview lasting up to 60 minutes that will be conducted either in person or via WebEx and recorded with your permission;
- Participate in up to two focus groups lasting up to 60 minutes that will be in person or on WebEx and recorded with your permission;
- Participate in routine school improvement activities lasting up to 60 minutes that will be observed by the researcher with researcher reflections being recorded using a laptop

computer. These include meetings related to school improvement, professional learning community meetings, and classroom instruction;
- Provide copies of lesson plans, assignments, student work, and other materials used in teaching or meetings related to the NIC;
- Review drafts of the completed research to provide feedback, guidance, and/or verification that the researcher has correctly represented your perspectives in the data.

WHAT ARE THE RISKS OF TAKING PART IN THE STUDY?

While participating in the study, you are not expected to experience any significant risks. However, in very rare cases, a participant in a qualitative research study may experience nervousness, agitation, or anxiety while being interviewed by the researcher or observed in their professional work setting. If this should occur, please tell the researcher that you feel uncomfortable or that you do not want to answer a particular question. You are not required to participate in any aspect of this research that makes you feel uncomfortable.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THE STUDY?

We don't expect you to receive any direct benefit from taking part in this study, but we hope to learn things that will help scientists in the future.

WILL I RECEIVE MY RESULTS?

The results from this research study may appear in published research articles, book chapters, books, and other scholarly outlets. In addition, you may request a copy of your completed interview transcript.

HOW WILL MY INFORMATION BE PROTECTED?

Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. No information that could identify you will be shared in publications about this study.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, and state or federal agencies who may need to access the research records (as allowed by law).

WILL MY INFORMATION BE USED FOR RESEARCH IN THE FUTURE?

Information collected from you for this study may be used for future research studies or shared with other researchers for future research. If this happens, information that could identify you will be removed before any information is shared. Because identifying information will be removed, we will not ask for your additional consent.

WILL I BE PAID FOR PARTICIPATION?

You will not be paid for participating in this study.

WILL IT COST ME ANYTHING TO PARTICIPATE?

There is no cost to you for taking part in this study.

WHO WILL PAY FOR MY TREATMENT IF I AM INJURED?

In the event of physical injury resulting from your participation in this study, necessary medical treatment will be provided to you and billed as part of your medical expenses. Costs not covered by your health care insurer will be your responsibility. Also, it is your responsibility to determine the extent of your health care coverage. There is no program in place for other monetary compensation for such injuries. However, you are not giving up any legal rights or benefits to which you are otherwise entitled. If you are participating in research that is not conducted at a medical facility, you will be responsible for seeking medical care and for the expenses associated with any care received.

WHO SHOULD I CALL WITH QUESTIONS OR PROBLEMS?

For questions about the study, contact the researcher, Holly Pate, at (812) 499-2612. After business hours, email the investigator at hjpate@iu.edu.

For questions about your rights as a research participant, to discuss problems, complaints or concerns about a research study, or to obtain information or to offer input, please contact the IU Human Subjects Office at 800-696-2949 or at irb@iu.edu.

CAN I WITHDRAW FROM THE STUDY?

If you decide to participate in this study, you can change your mind and decide to leave the study at any time in the future. The study team will help you withdraw from the study safely. If you decide to withdraw, please email the researcher at hjpate@iu.edu.

PARTICIPANT'S CONSENT

In consideration of all of the above, I give my consent to participate in this research study. I will be given a copy of this informed consent document to keep for my records. I agree to take part in this study.

Participant's Printed Name:_____

Participant's Signature:_____**Date**:_____

Printed Name of Person Obtaining Consent:_____

Signature of Person Obtaining Consent:_____**Date**:_____

Appendix C

Study Information Sheet

INDIANA UNIVERSITY STUDY INFORMATION SHEET FOR RESEARCH

A Qualitative Study of Principal and Teacher Perspectives on Implementing Improvement Science in a NIC Focused on Elementary Mathematics

IRB Protocol Number: 2011849337

ABOUT THIS RESEARCH

You are being asked to participate in a research study. Scientists do research to answer important questions that might help change or improve the way we do things in the future.

This form will give you information about the study to help you decide whether you want to participate. Please read this form and ask any questions you have before agreeing to be in the study.

TAKING PART IN THIS STUDY IS VOLUNTARY

You may choose not to take part in the study or may choose to leave the study at any time. Deciding not to participate or deciding to leave the study later will not result in any penalty or loss of benefits to which you are entitled and will not affect your relationship with your college or university.

WHY IS THIS STUDY BEING DONE?

The purpose of this study is to understand how school principals and teachers work in an emerging networked improvement community (NIC) focused on elementary mathematics.

You were selected as a possible participant because of your membership in the NIC.

The study is being conducted by Holly Pate, doctoral student at Indiana University Bloomington.

HOW MANY PEOPLE WILL TAKE PART?

If you agree to participate, you will be one of up to eight participants taking part in this study.

WHAT WILL HAPPEN DURING THE STUDY?

If you agree to be in the study, you will do the following things:

- Participate in one semistructured interview lasting up to 60 minutes that will be conducted either in person or on Zoom and recorded with your permission;
- Participate in up to two focus groups lasting up to 60 minutes that will be in person or on Zoom and recorded with your permission;
- Participate in routine school improvement activities lasting up to 60 minutes that will be observed by the researcher with researcher reflections being recorded using a laptop computer. These include meetings related to school improvement, professional learning community meetings, and classroom instruction;
- Provide copies of lesson plans, assignments, student work, and other materials used in teaching or meetings related to the NIC;
- Review drafts of the completed research to provide feedback, guidance, and/or verification that the researchers' have correctly represented your perspectives in the data.

WHAT ARE THE RISKS OF TAKING PART IN THE STUDY?

While participating in the study, you are not expected to experience any significant risks. However, in very rare cases, a participant in a qualitative research study may experience nervousness, agitation, or anxiety while being interviewed by the researcher or observed in their professional work setting. If this should occur, please tell the researcher that you feel uncomfortable or that you do not want to answer a particular question. You are not required to participate in any aspect of this research that makes you feel uncomfortable.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THE STUDY?

We don't expect you to receive any direct benefit from taking part in this study, but we hope to learn things that will help scientists in the future. Additionally, you might find it beneficial to reflect on your practice by participating in the semistructured interview.

WILL I RECEIVE MY RESULTS?

The results from this research study may appear in published research articles, book chapters, books, and other scholarly outlets. In addition, you may request a copy of your completed interview transcript.

HOW WILL MY INFORMATION BE PROTECTED?

Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. No information that could identify you will be shared in publications about this study.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana

University Institutional Review Board or its designees, and state or federal agencies who may need to access the research records (as allowed by law).

WILL MY INFORMATION BE USED FOR RESEARCH IN THE FUTURE?

Information collected from you for this study may be used for future research studies or shared with other researchers for future research. If this happens, information that could identify you will be removed before any information is shared. Because identifying information will be removed, we will not ask for your additional consent.

WILL I BE PAID FOR PARTICIPATATION?

You will not be paid for participating in this study.

WILL IT COST ME ANYTHING TO PARTICIPATE?

There is no cost to you for taking part in this study.

WHO WILL PAY FOR MY TREATMENT IF I AM INJURED?

In the event of physical injury resulting from your participation in this study, necessary medical treatment will be provided to you and billed as part of your medical expenses. Costs not covered by your health care insurer will be your responsibility. Also, it is your responsibility to determine the extent of your health care coverage. There is no program in place for other monetary compensation for such injuries. However, you are not giving up any legal rights or benefits to which you are otherwise entitled.

WHO SHOULD I CALL WITH QUESTIONS OR PROBLEMS?

For questions about the study, contact the researcher, Holly Pate, at (812) 499-2612. After business hours, email the investigator at hjpate@iu.edu.

For questions about your rights as a research participant, to discuss problems, complaints or concerns about a research study, or to obtain information or to offer input, please contact the IU Human Subjects Office at 800-696-2949 or at irb@iu.edu.

CAN I WITHDRAW FROM THE STUDY?

If you decide to participate in this study, you can change your mind and decide to leave the study at any time in the future. The study team will help you withdraw from the study safely. If you decide to withdraw, please email the researcher at hjpate@iu.edu.

Appendix D

Title: Studying Principal and Teacher Perspectives on Implementing Improvement Science in a NIC Focused on Elementary Mathematics

Observation Guide

Description of the Observational Approach

The researcher will conduct observations in classrooms and at schools. Observations will occur during meetings related to school improvement planning, specifically improvement activities focused on elementary mathematics. The observations will seek to corroborate what participants describe within the context of semistructured interviews, focus groups, and what I identify in school and district documents. During observations, I will record my observations on a laptop computer. The notes will be saved electronically and uploaded to a computer-assisted qualitative data analysis software package. Files will be stored without reference to individual participants. Participant names will be replaced with generic identifiers (e.g., teacher, principal, etc.).

Classroom Observations

The purpose of my classroom observations is to identify how teachers use improvement science to address a problem of practice within the context of their classroom practice. In observing classroom instruction, I seek to determine whether improvement science processes permeate the classroom environments, inform teacher decision-making, and influence what instructional activities teachers plan/provide. I anticipate that each classroom observation will last no more than 60 minutes and will focus exclusively on teacher instructional behaviors.

Specific data points may include the following:

- Displays of learning improvement goals or improvement priorities
- Displays of data and/or assessment information that document progress
- Evidence of PDSA cycles or other improvement science tools
- Displays of learning objectives and/or lesson goals
- Interactions between teachers and students that align with improvement goals
- Statements offered by teachers that support or align with improvement goals

School Level Observations

The purpose of my school-level observations is to identify how the school engages in improvement planning, uses PDSA cycles as part of their planning efforts, adopts improvement science tools (e.g., Fishbone and/or Driver Diagrams), and what the principal and his/her leadership team do to facilitate this process. During school-based observations, I will seek evidence that describes how (if at all) the principal alters his or her work approach to school improvement and how teachers discuss improvement processes. I will note exchanges, interactions, and conversations between the principal and other school members that relate to school improvement. To enhance these opportunities to observe these exchanges, I will observe school improvement planning meetings,

PLC meetings that include NIC members, and school-wide professional development related to school improvement planning.

Specific data points may include the following:

- Displays of learning improvement goals or improvement priorities
- Displays of data and/or assessment information that document progress
- Evidence of PDSA cycles, driver diagrams, or fish bone diagrams
- Interactions between administrators and teachers that align with improvement goals
- Statements offered by administrators or teachers that support or align with improvement goals
- Activities (e.g., professional development) aligned with implementation of improvement science for school improvement purposes
- Analytic activities that support school-wide data analysis, interpretation, or sense making

Appendix E

Principal Interview Protocol

Introduction

My name is Holly Pate, and I am a doctoral student at Indiana University studying the implementation of improvement science for the purposes of school improvement.

In this interview, I am going to ask you about school improvement processes and teacher support. As we talk, I'd like you to consider the processes you implement based on your learning about improvement science.

This interview should take no more than 60 minutes. With your permission, I will record the interview. Do I have your permission to begin the recording?

I. *We will begin with a few questions about your school improvement process.*

- Broadly describe your school's approach to the school improvement process.
    - Who is involved in the process of identifying and setting improvement goals or performance targets?
    - What data are used within this process to articulate problems, identify performance concerns, or raise issues as potential action items?
    - How are data analyzed within the improvement process?
    - How are action steps derived once the results of the data analysis have been completed?
    - How has your approach to school improvement evolved over the course of your principalship?
        - Can you give me a specific example?
    - How are teams held accountable to making progress?
    - How is support differentiated based on the success or struggles of the teacher or team?
        - Can you give me a specific example?

II. *Now, I will ask you some questions about working with teachers for school improvement.*

- What support do you provide to assist teacher teams or individual teachers involved in the NIC when planning or implementing improvement strategies?
    - In what form is this support most often provided?
    - To what extent is your support differentiated across the teams or teachers you serve?
    - What measures, metrics, or data points, if any, do you commonly use to differentiate the support you provide to teachers or teacher teams?
    - What are common challenges that teachers or teacher teams encounter when engaging in school improvement planning?
    - How do you support teachers or teacher teams to address, resolve, or mitigate these challenges?
        - Can you give me a specific example?

    - Describe your support of teachers or teams that are not involved in the NIC.
- What support do you provide to assist teacher teams or individual teachers who are not involved in the NIC when planning or implementing improvement strategies?
    - In what form is this support most often provided?
    - To what extent is your support differentiated across the teams or teachers you serve?
    - What measures, metrics, or data points, if any, do you commonly use to differentiate the support you provide to teachers or teacher teams?
    - What are common challenges that teachers or teacher teams encounter when engaging in school improvement planning?
    - How do you support teachers or teacher teams to address, resolve, or mitigate these challenges?
        - Can you give me a specific example?

Appendix F

Teacher Interview Protocol

Introduction

My name is Holly Pate, and I am a doctoral student at Indiana University studying the implementation of improvement science for the purposes of school improvement.

In this interview, I am going to ask you about instructional practice, improvement processes, and collaboration. As we talk, I'd like you to consider your improvement processes and collaborative interactions based on your learning about improvement science.

This interview should take no more than 60 minutes. With your permission, I will record the interview. Do I have your permission to begin the recording?

I. *We will begin with a few questions about your improvement process.*

- Describe your role in the networked improvement community both within your school and across schools.
    - How do you assist in identifying priorities for improvement?
    - What information, evidence, or data do you use to facilitate this identification?
    - What process or processes do you use to identify problems or challenges?
    - How do you determine the reason(s) this problem or challenge exists?
    - How do you select an intervention to address the problem or challenge?
- To what extent do you consult research and/or technical guidance to develop interventions that respond to your team's improvement concerns?
        - From which sources or organizations do you most commonly draw this information?
        - What types of information do you find most helpful or beneficial?
        - How do you share this information with your colleagues and peers?
    - How, if at all, is this information used?
- How do you know whether an intervention or change has produced the results you intended?
    - What measures and/or metrics do you commonly use?
    - From where is the information generally obtained?
    - How do you analyze, assess, or evaluate the information you receive?
- What do you do if the intervention or change fails to produce the desired results?
    - With whom do you discuss next steps?
    - How do you prepare to modify the intervention or change?
    - What evidence do you use to guide/inform these modifications?
    - How often do you engage in this revision process?
    - What prompts you to stop revising the intervention?

II. *Now, I will ask you some questions about working with teachers on school improvement.*

- What structures or practices are used for collaboration?
    - How are data used within these structures or practices?

        - Can you provide a specific example?
    - How are problems or challenges defined?
        - Can you provide a specific example?
- What structures or practices facilitate collaboration on issues of improvement?
    - Could you provide a specific example?
- What structures or practices prevent collaboration on issues of improvement?
- Do you collaborate with colleagues in other school sites on common improvement issues?
    - If so, how does this collaboration with colleagues in other school sites occur?
    - If not, how would this kind of collaboration support your school improvement efforts?
- How, if at all, do you share learning from your improvement efforts?
    - With whom do you share these learnings?
        - Can you provide a specific example?

Appendix G
Document Collection Guide

I will collect the below documents throughout the duration of the research study. These documents will be used to corroborate participants understanding of the school and team's implementation of improvement science as an approach to school improvement. Documents that are not publicly available are noted with an asterisk. Documents will be stored on a secure file server hosted by Indiana University. Personally identifiable information will be removed prior to storing the data.

School Documents and Artifacts

- Current School Improvement Plan*
- School Achievement Goals*
- School Report Card (prepared online by Indiana Department of Education)
- Current Enrollment, Demographic, and Achievement Information
- Collaboration Schedule*
- Professional Learning Team Rosters (with names of teachers removed) *
- Improvement Meeting Agendas and Notes*

Professional Learning Community (PLC) Documents and Artifacts

- PLC Norms and Decision-Making Protocols*
- PLC Collaboration Schedules*
- Decision-Making Templates*
- Data Analysis Templates*
- Improvement Meeting Agendas and Notes*

Principal and Teacher Leader Documents and Artifacts

- Professional Development Agendas*
- Professional Development Presentations*
- Improvement Meeting Agendas and Notes*
- Informal Communications Sent to School Staff about School Improvement*

Teacher Documents and Artifacts

- Lesson Plans*
- Lesson Presentations*
- Worksheets or Other Documents Provided to Students During the Lesson*
- Student Work Samples (with student names or identifiers removed) *
- Informal Communications Sent to School Staff about School Improvement*
- Data Trackers (with school, teacher, and student identifiers removed) *

Appendix H

Document Collection Protocol

To: Research Participants

From: Holly Pate
Doctoral Student
Indiana University

Subj: Documents Requested for Research Study

The purpose of this study is to understand how school principals and teachers work in an emerging networked improvement community (NIC) focused on elementary mathematics. I am requesting that you provide copies of the following documents to assist me with my research. The documentation you provide should not contain identifiable information. The information will be a stored on a secure server hosted by Indiana University Bloomington.

School Documents and Artifacts

- Current School Improvement Plan*
- School Achievement Goals*
- School Report Card (prepared online by Indiana Department of Education)
- Current Enrollment, Demographic, and Achievement Information
- Collaboration Schedule*
- Professional Learning Team Rosters (with names of teachers removed) *
- Improvement Meeting Agendas and Notes*

Professional Learning Community (PLC) Documents and Artifacts

- PLC Norms and Decision-Making Protocols*
- PLC Collaboration Schedules*
- Decision-Making Templates*
- Data Analysis Templates*
- Improvement Meeting Agendas and Notes*

Principal and Teacher Leader Documents and Artifacts

- Professional Development Agendas*
- Professional Development Presentations*
- Improvement Meeting Agendas and Notes*

- Informal Communications Sent to School Staff about School Improvement*

Teacher Documents and Artifacts

- Lesson Plans*
- Lesson Presentations*
- Worksheets or Other Documents Provided to Students During the Lesson*
- Student Work Samples (with student names or identifiers removed) *
- Informal Communications Sent to School Staff about School Improvement*
- Data Trackers (with school, teacher, and student identifiers removed) *

The information can be sent to Holly Pate via email as a PDF document or U.S. Postal Mail. Her contact information is provided below.

Holly Pate
EVSC
951 Walnut St.
Evansville, IN 47713
(812) 499-2612
hjpate@iu.edu

Appendix I

Verbal Script
Research Participant Recruitment

I'm Holly Pate, a doctoral student at Indiana University in the Educational Leadership program. I am excited to invite you to participate in a research study that will explore your experiences in the elementary mathematics networked improvement community (NIC) within the Midwest School District (MSD). You are being asked to participate in this study because of your involvement in the NIC. If you agree to participate, you will be asked to complete an interview, participate in a focus group with colleagues from the NIC, participate in observations of instructional practice and planning opportunities related to the focus of your NIC, and provide copies of documents that demonstrate your implementation of NIC activities and processes. This information will be used to better understand the use of NIC processes and how this informs teaching and learning. In addition, it will help other schools and districts learn about your experiences within an emerging NIC.

Your participation in this study is entirely voluntary. You will not be penalized in any way if you choose not to participate. As a research participant, you have certain protections, which I will explain when we discuss the informed consent form I sent to you via email. At this time, I would like to answer any questions you have regarding what you may be asked to do if you participate in this study.

Appendix J

Email for Staff in Schools where Observations will be Conducted

To: School Staff of Rolling Hills and Main Schools

From: Holly Pate

Subject: Your School's Participation in my Dissertation Research Study

This email is to inform you that colleagues from your school are participating in a research study I am conducting for my dissertation at Indiana University. This study seeks to understand how a networked improvement community in elementary mathematics uses certain processes as an approach to school improvement and how this informs teaching and learning.

As part of this study, I will be conducting observations in your school during a typical school day. Observations will occur in specific classrooms and in public spaces. The observations are to see how the NIC processes are implemented. Any information I record will not identify your name, classroom, or school.

If you have any questions, you are welcome to contact me via email at hjpate@iu.edu or by phone at 812-499-2612. In addition, you are welcome to contact the Indiana University Institutional Review Board with questions about your rights as a research participant. They can be contacted at irb@iu.edu.

Appendix K

Letter for Parents of Students in Classrooms Being Observed

To: Parents of Children at Rolling Hills and Main Schools

From: Holly Pate

Subject: Your Child's Classroom is Participating in an IU Research Study

This letter is to inform you that your child's classroom teacher is participating in a research study being conducted by a doctoral student at Indiana University. This study seeks to understand how a networked improvement community (NIC) in elementary mathematics uses certain processes as an approach to school improvement and how this informs teaching and learning.

As part of this research study, I will be conducting observations in your child's classroom and school during the regular school day. The purpose of this observation is to simply see how your school uses the improvement process as part of its work. Any information recorded using laptop computers or notepads will not identify your child's name, classroom, or school.

If you have any questions, you are welcome to contact me via email at hjpate@iu.edu or by phone at 812-499-2612. In addition, you are welcome to contact the Indiana University Institutional Review Board with questions about your child's rights as a research participant. They can be contacted at irb@iu.edu.

Thank you for your assistance.

Sincerely,

Holly Pate
Doctoral Student
Indiana University
School of Education
hjpate@iu.edu
(812)499-2612

Appendix L

Verbal Script
Announcing Classroom Observations to Students

Hello. My name is Mrs. Pate, and I am a student at Indiana University. Your teacher (insert name) is working with me in a research study. I am learning about the work she does and am here today to learn more about how she works with you in your classroom. I will be taking notes on my laptop. I am not writing about you. Instead, I am writing about how your teacher works with you. I may write something like, "(Insert teacher name) models a math problem on the whiteboard." I will also write about how your classroom looks and what I see posted on the walls. I am happy to answer questions you have about my visit. Thank you for sharing your classroom with me. I am excited to learn with you today.

Appendix M

Focus Group Protocol

Introduction

My name is Holly Pate, and I am a doctoral student at Indiana University studying the implementation of improvement science for the purposes of school improvement.

In this focus group, I am going to ask you about instructional practice, improvement processes, support, and collaboration. As we talk, I'd like you to consider your improvement processes and collaborative interactions based on your learning about improvement science and your work within the networked improvement community.

This focus group should take no more than 60 minutes. With your permission, I will record the interview. Do I have your permission to begin the recording?

I. Let's begin with some questions about your PDSA process.

- How did your team design your most recent PDSA?
    - How did you identify your shared problem of practice?
    - What data, metrics, or other information do you use to determine the problem of practice?
    - How were your conversations structured when designing your PDSA?
        - Could you provide a specific example?
    - How did you develop your change idea?
    - What challenges did you experience? How did your teamwork through these challenges?
    - What did you learn while planning your PDSA as a team?
    - What barriers did you encounter when planning your PDSA as a team?

- How have you implemented your most recent PDSA?
    - What interactions with your team have been most beneficial in the "Do" phase of implementation?
        - Could you provide a specific example?
    - What actions help improve consistency across classrooms?
    - What obstacles have occurred in implementing a shared PDSA? How has that impacted your work?
    - How have you determined what is or is not working across the team?
    - How have you navigated challenges?

- Thinking back to your most recent PDSA cycle, how did it work?
    - How did your team decide to adopt, adapt, or abandon your PDSA?
    - What results did you use to make a final decision?
    - Based on your decision, how did your team move forward?

- How has the development of your PDSA changed your work together?

- What are some examples of the changes you've seen?
- How does this differ from other professional relationships you have?

II. Now, I will ask you a few questions about support of school improvement work and PDSAs.

- What support is provided to assist teacher teams or individual teachers involved in the NIC when planning or implementing improvement strategies?
  - In what form is this support most often provided?
  - To what extent is the support differentiated across the teams or teachers?
    - Could you provide a specific example?
  - What are common challenges that you encounter when engaging in school improvement planning?
  - What type of support is provided to address, resolve, or mitigate these challenges?
    - Can you give me a specific example?
  - What structures or practices facilitate support?
    - Can you give me a specific example?
  - What structures or practices impede this support?
    - Can you provide a specific example?

III. Now, I will ask you some questions about working with others on school improvement.

- How, if at all, do you share learning from your improvement efforts?
  - With whom do you share these learnings?
    - Can you provide a specific example?
  - What structures or practices facilitate this type of collaboration?
    - Can you provide a specific example?
  - What structures or practices prevent collaboration of this type?
    - Can you provide a specific example?

- Do you collaborate with colleagues in other school sites on improvement issues or PDSAs?
  - If so, how does this collaboration with colleagues in other school sites occur?
    - What structures or practices facilitate this type of collaboration?
    - What structures or practices prevent this type of collaboration?
  - If not, how would this kind of collaboration support your school improvement efforts?

Figure 3.

Data Analysis

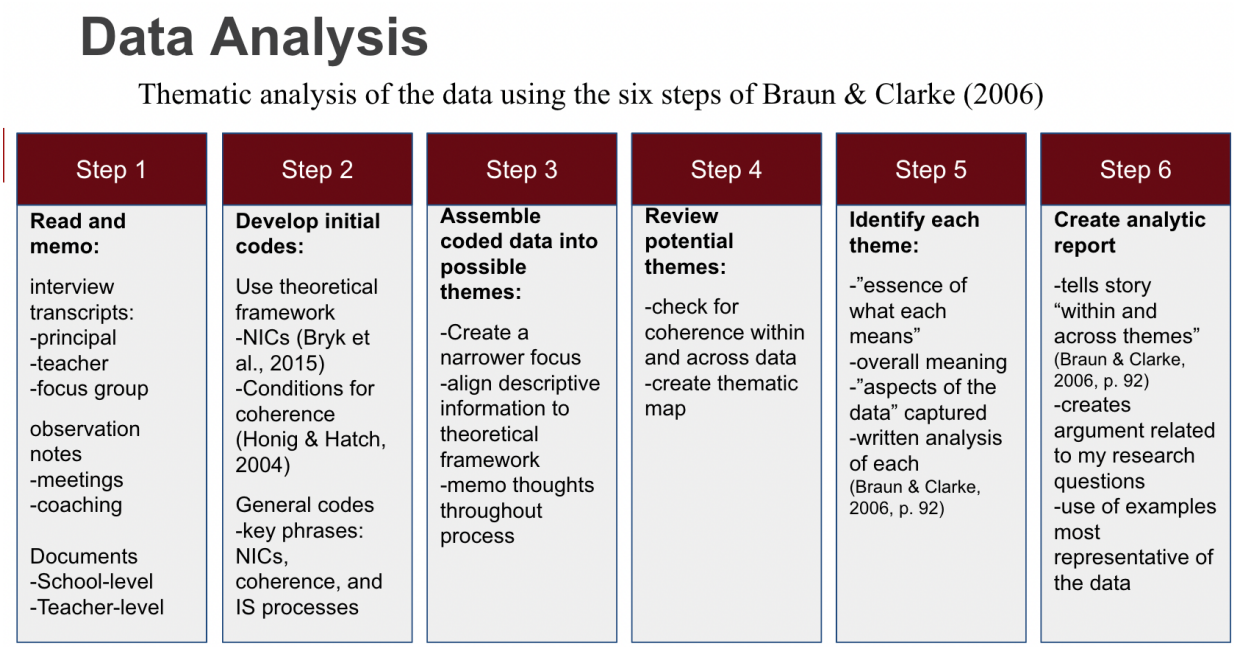


Figure 4

Main School Fishbone v. 1

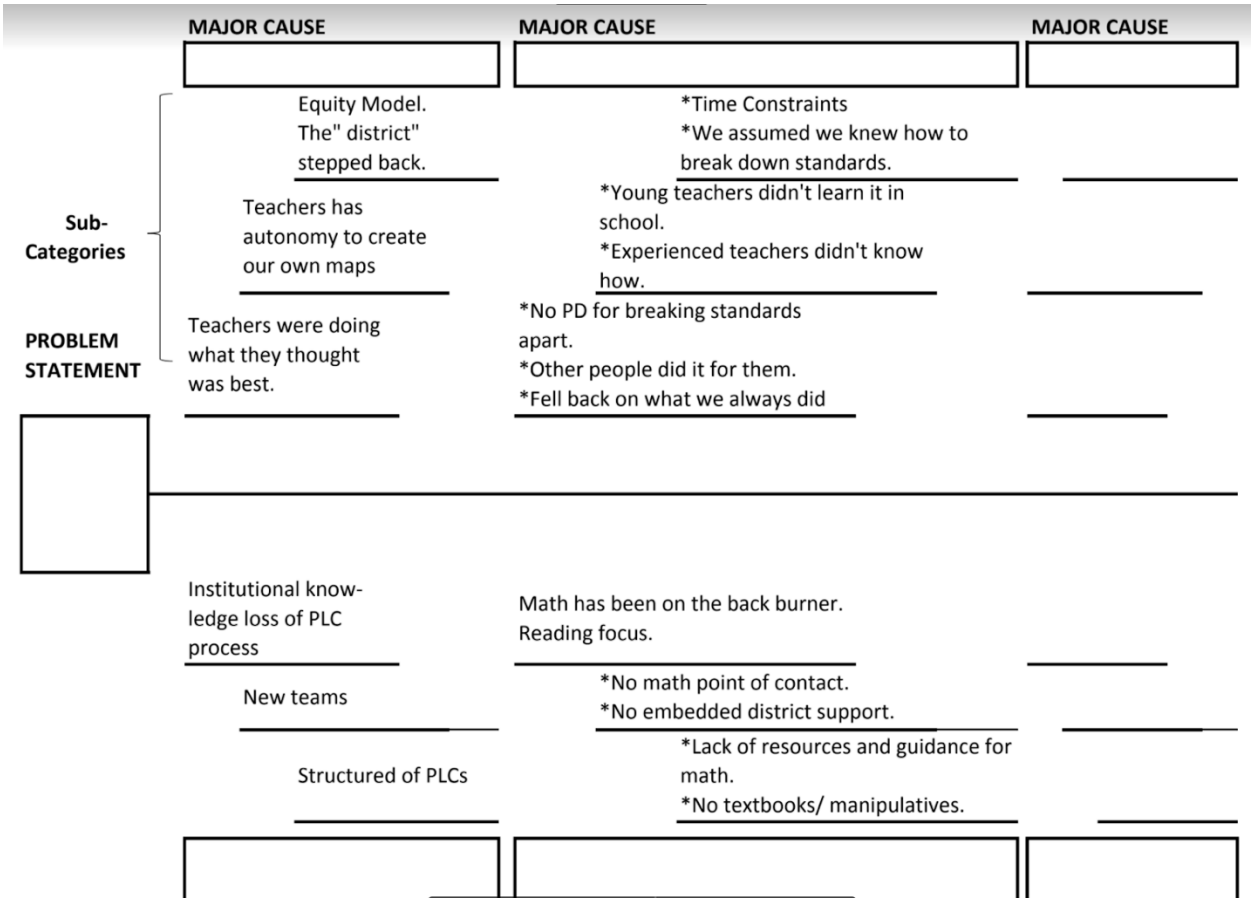


Figure 5

Main School Fishbone v. 2

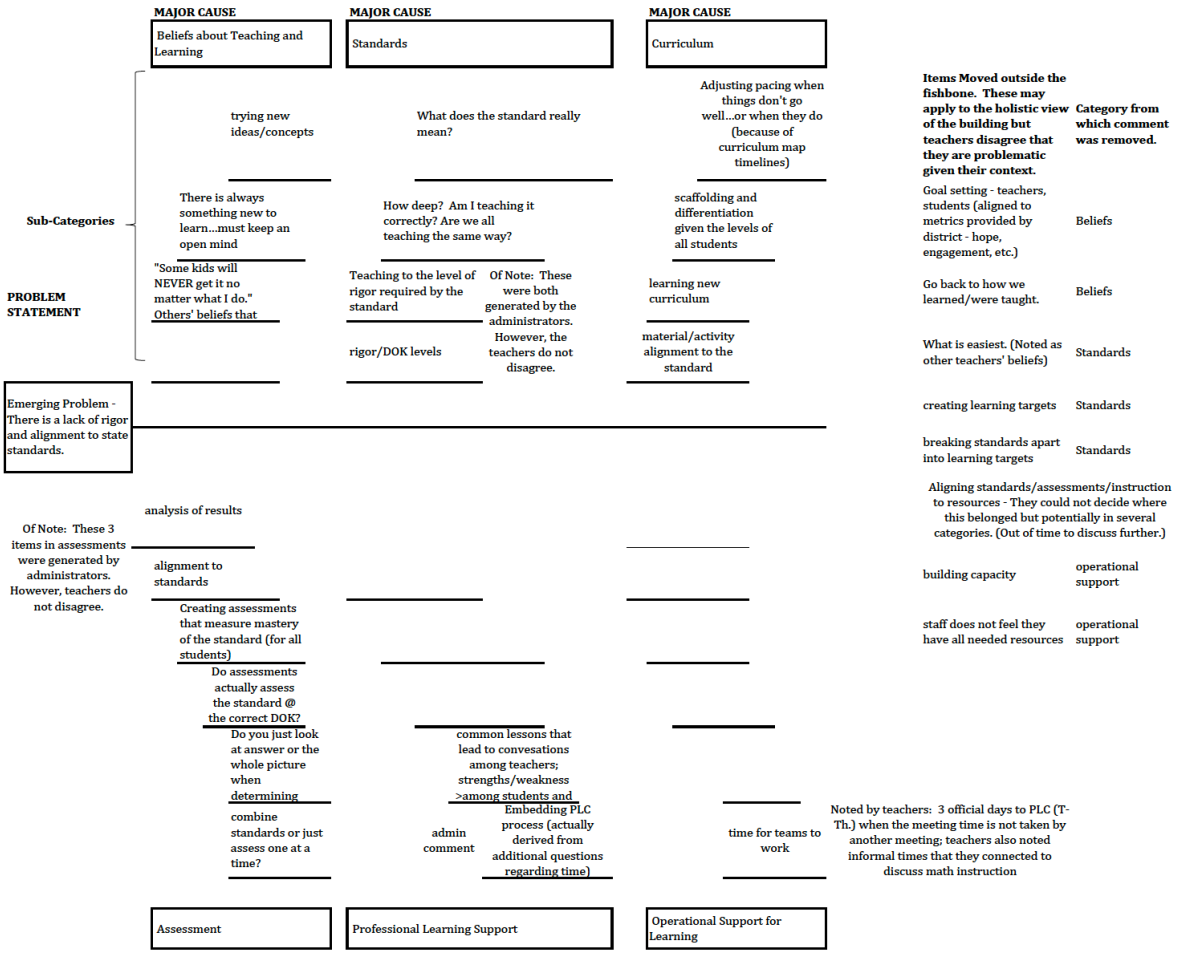


Figure 6

Main School Fishbone v. 3

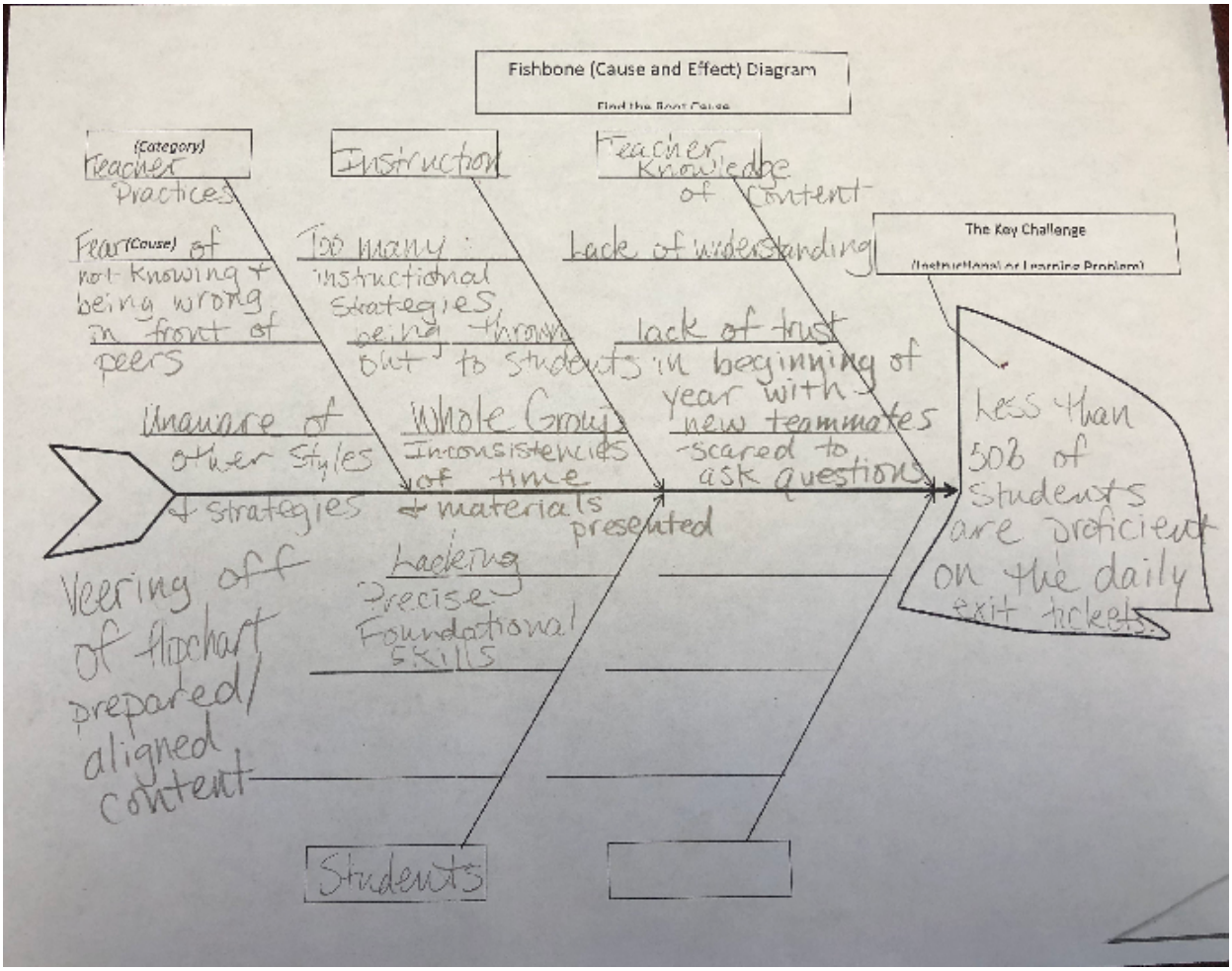


Figure 7

Rolling Hills Fishbone v. 1

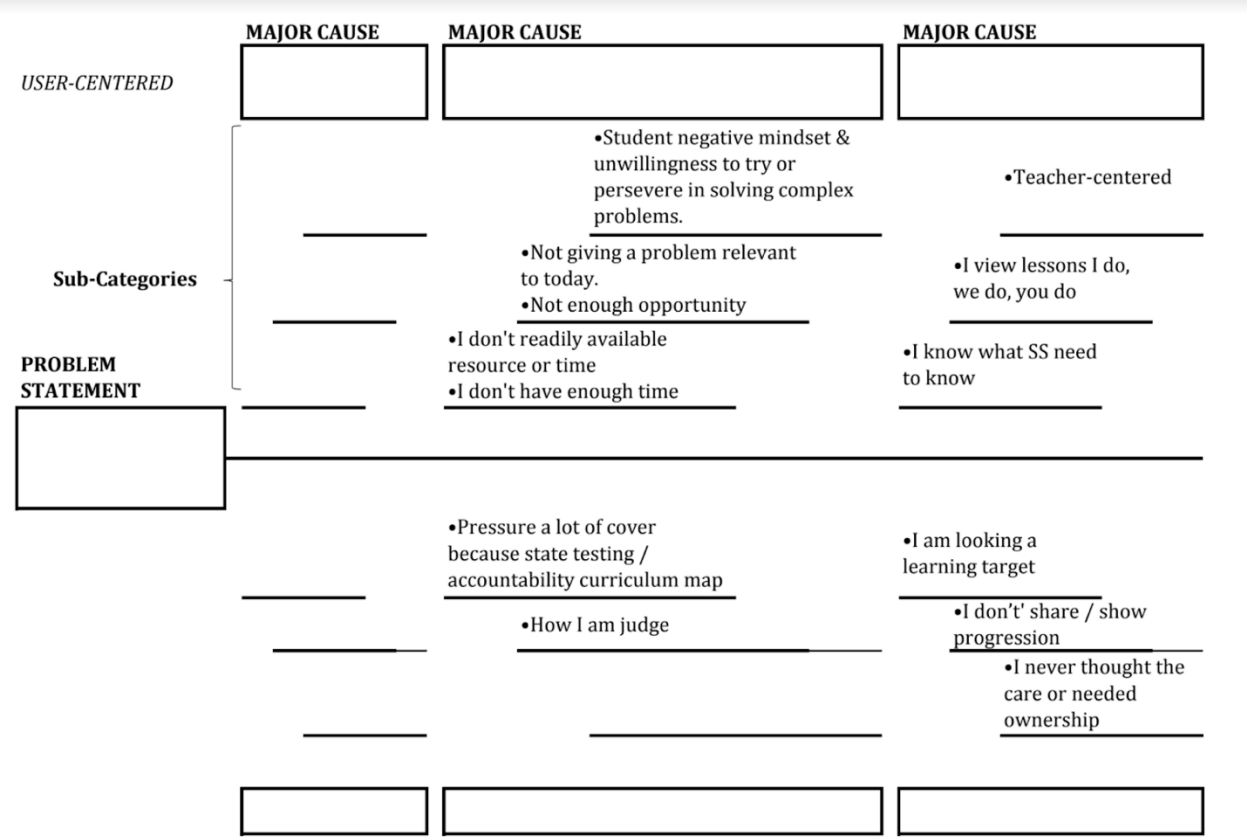


Figure 8

Rolling Hills Fishbone v. 2

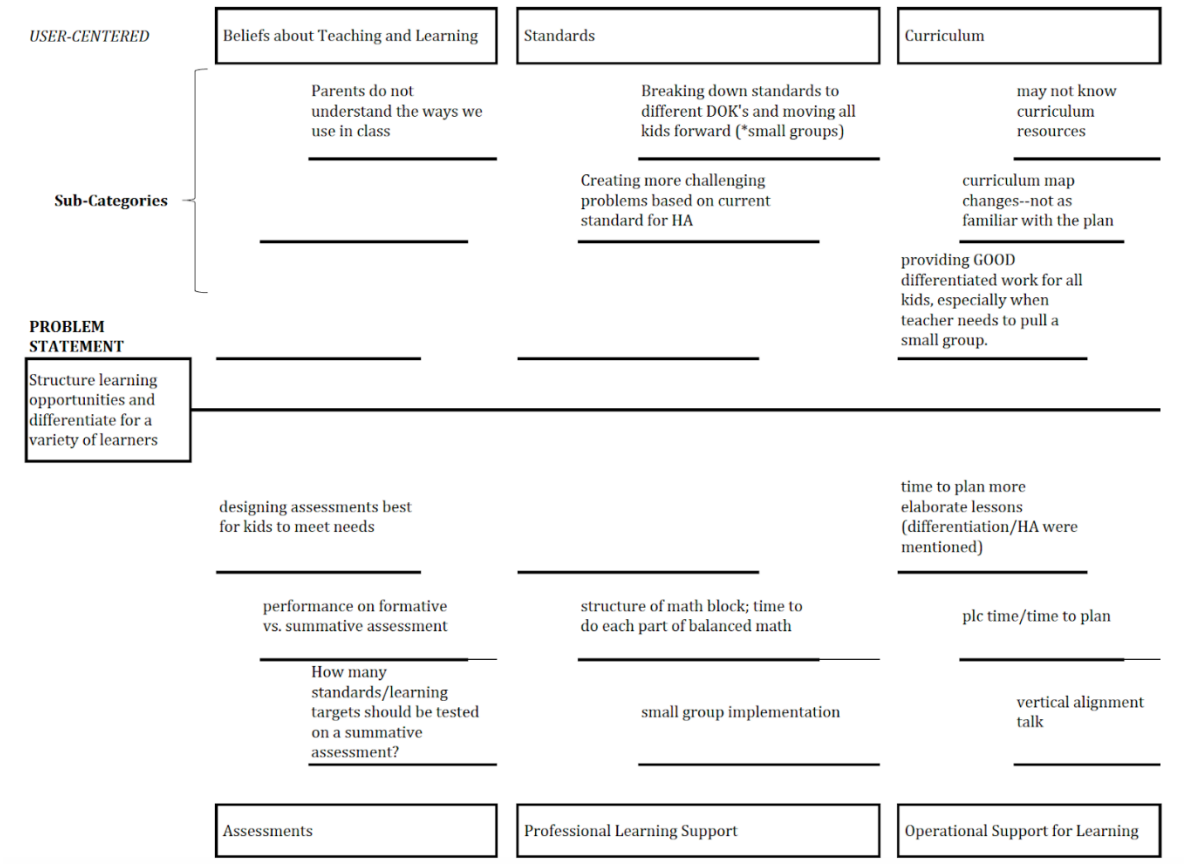
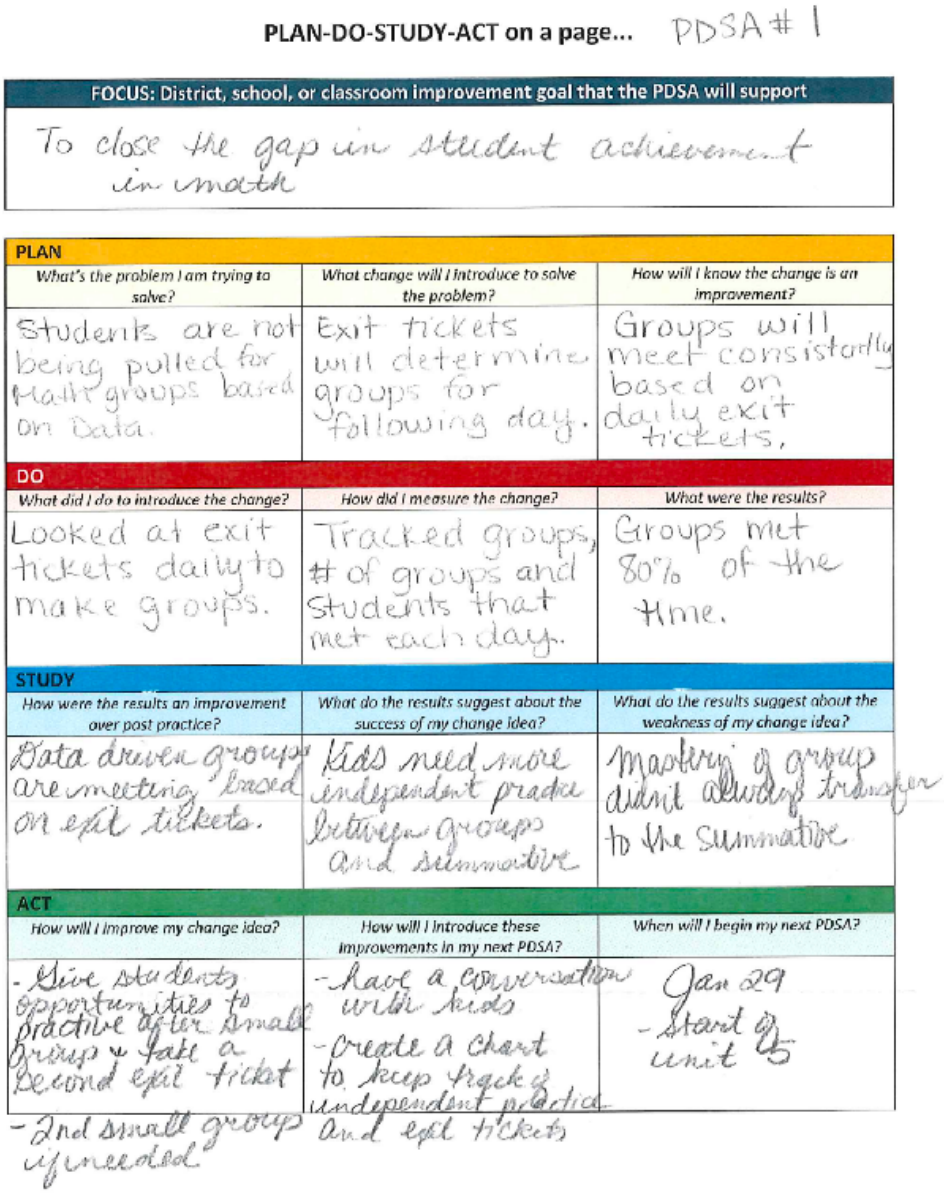


Figure 9

Main School PDSA on a Page



PLAN-DO-STUDY-ACT on a page... PDSA # 1

FOCUS: District, school, or classroom improvement goal that the PDSA will support

To close the gap in student achievement in math

PLAN

What's the problem I am trying to solve?	What change will I introduce to solve the problem?	How will I know the change is an improvement?
Students are not being pulled for Math groups based on Data.	Exit tickets will determine groups for following day.	Groups will meet consistantly based on daily exit tickets.

DO

What did I do to introduce the change?	How did I measure the change?	What were the results?
Looked at exit tickets daily to make groups.	Tracked groups, # of groups and students that met each day.	Groups met 80% of the time.

STUDY

How were the results an improvement over past practice?	What do the results suggest about the success of my change idea?	What do the results suggest about the weakness of my change idea?
Data driven groups are meeting based on exit tickets.	Kids need more independent practice between groups and summative	Mastery of group didn't always transfer to the summative

ACT

How will I improve my change idea?	How will I introduce these improvements in my next PDSA?	When will I begin my next PDSA?
- Give students opportunities to practice after small groups & take a second exit ticket - 2nd small group if needed	- Have a conversation with kids - Create a chart to keep track of independent practice and exit tickets	Jan 29 - Start of unit 5

Table 2

PDSA Cycle Question Stems Tool

		PDSA Cycle Questions from Form:	Potential Coaching Stems:
PLAN	This step clarifies the problem and identifies the overall aim; the tool, process, or change to implement; and more specific targets or objectives of the continuous improvement process.	What is your current understanding of the specific problem you are trying to solve?	-What is the specific problem you are trying to solve? -What was the change idea you used? -How did you identify this problem? -Can you share the data/evidence that helped you determine this problem of practice?
		What do you predict will happen after introducing your change idea?	-What specifically are we trying to accomplish? -How does this align with your driver diagram/AIM statement?
		What logistical considerations should be made before introducing this change idea?	-What do we need to do or consider in advance to be ready to introduce the change idea?
		What measures will be utilized and when do you anticipate gathering those measures?	-How will we know what change is an actual improvement? -Where have (or will) you insert(ed) points along the way to check to see if what you're doing is working?
		Questions or comments I have about improvement science or the "plan" phase.	
DO	This step involves the implementation of the tool, process, or change and the collection of both process and outcome data.	How are you implementing your current change idea?	-How is it working? -Are there additional implementation metrics that need to be implemented to create a structure for success? -Were the logistical considerations made in the planning phase helpful to implementation?
		What is your data telling you about the change idea you are implementing?	-Are the data supporting your prediction? Why or why not? -What type of variation I evidenced in the data? What can we learn from the variation?
		How are students responding to the change idea you have introduced?	-Is there evidence the change idea is resulting in improvement toward the desired outcomes?
		What unexpected challenges or results have you encountered?	-What results or occurrences did you observe beyond your original prediction? Have you/did you adjust anything midprocess? What prompted the adjustment? -Are there additional supports you need from the district design team to help you in this phase of the PDSA? From your principal?
		Questions or comments I have about improvement science or the "do" phase.	
STUDY	In this step, participants examine the collected data and consider the extent to which the specific targets or objectives met those identified in the plan step, as well as the overall aim.	How did the change idea influence the outcome you were hoping to achieve?	What were you trying to accomplish? How do you know the change is an improvement? What evidence do you have to support that the change influenced the outcome?
		What did you learn after implementing your change idea?	What effect did the change idea have? What adjustments need to be made to the system you used to track/collect data to determine success? What further considerations do you have now after reviewing the data?
		What adjustments do you think you need to make to be more successful?	What was the improvement metric you used to measure the outcome? What do you see as the difference between an implementation metric vs. improvement metric? What adjustments need to be made to help you have a bigger impact on your change idea?
		What is your plan for making and introducing these adjustments?	What is your process/protocol for introducing adjustments to ensure success? If your change idea did not have the impact, can you identify if it was an ineffective change idea or if there was a break down in the execution of the plan?
		Questions or comments I have about improvement science or the "study" phase.	What were you trying to accomplish? How do you know the change is an improvement? What evidence do you have to support that the change influenced the outcome?

ACT	This last step integrates all the learning generated throughout the process. The stakeholders, as needed, make adjustments to the specific objectives or targets, formulate new theories or predictions, make changes to the overarching aim of the continuous improvement work, and/or modify any tools or processes being tested.	What impact has the change idea had on your work as a classroom teacher/principal?	How are you using what you learned from the last PDSA to inform your work and prepare for the next cycle?
		What impact has the change idea had on your student's thinking, results, or behavior?	What was the desired/predicted impact of the change idea on student outcomes?
		What supports or resources do you need for the next iteration of your PDSA?	
		When do you anticipate the next PDSA cycle will begin?	Have you created a clear timeline to ensure you can implement the PDSA with fidelity?
		Questions or comments I have about improvement science or the "act" phase.	

Holly Pate, Ed. S.

Professional Summary

Educational leader with over 33 years of experience leading and collaborating with educators to improve students' opportunities at the district, school, and classroom levels. My leadership experiences center on curriculum and instruction, instructional coaching, and mentoring.

Education

ED.D. | EXP. 2023 | INDIANA UNIVERSITY, BLOOMINGTON, IN
Major: Educational Leadership
Minor: Education Law
Honors: Mary Margaret & Denzil Webb School Administration Fellowship

IMPROVEMENT SCIENCE CERTIFICATE | 2022 | INDIANA UNIVERSITY, BLOOMINGTON, IN

ED.S. | 2021 | INDIANA UNIVERSITY, BLOOMINGTON, IN
Major: Educational Leadership/Administration

- Superintendent's License

EDUCATION LAW CERTIFICATE | 2019 | INDIANA UNIVERSITY, BLOOMINGTON, IN

ADMINISTRATOR LICENSURE PROGRAM | 2016 | INDIANA UNIVERSITY, BLOOMINGTON, IN

- EVSC Cohort
- Building Administrator License

M.ED. | 1994 | INDIANA WESLEYAN UNIVERSITY, MARION, IN
Focus: Education
Honors: Outstanding Professional Award

B.A. |1989 | UNIVERSITY OF EVANSVILLE, EVANSVILLE, IN
Major: K-12 Special Education

- Licensure areas: Learning Disabilities, Mild Mental Disabilities, Emotional Disabilities, Severe Disabilities

K-12 Experience

DIRECTOR OF K-12 MATHEMATICS AT EVANSVILLE-VANDERBURGH SCHOOL CORPORATION | EVANSVILLE, IN | 2016-PRESENT

Collaboration with External Institutions

- EVSC/TNTP Partnership Coordinator|2022 ongoing |Leading partnership for a comprehensive assessment of the Mathematics Program with an eye to implementation of new curriculum and instructional shifts in 23–24
    - Assessed current mathematics instruction through over 300 walkthroughs and data analysis
    - Garnered stakeholder input, including teachers, principals, and district leaders, leading to additional input with the community as well as a teacher "test drive" of the curriculum
    - Researched and evaluated highly rated curricular options through the lens of district vision
    - Structured curriculum advisory group to allow curriculum discussion according to Indiana Code
    - Developed a robust implementation plan working with stakeholders across multiple

departments
    - Trained district and building leaders to prepare for implementation
- EVSC/IU iLead Partnership District Coordinator | 2017–2020 | Improvement Leadership and Education Development (iLead) in partnership with IU and the Carnegie Foundation for the Advancement of Teaching
    - Responsible for district coordination of EVSC/IU partnership
    - Codeveloped a networked improvement community for elementary mathematics that included principals and teachers from three schools in coordination with other district leaders and IU faculty
    - Cofacilitated summer iLead Institute and subsequent professional development sessions with IU Faculty, as well as facilitating additional sessions with principals and teachers
    - Cofacilitated iLead design team meetings of all stakeholders, including the superintendent, deputy superintendents, IU partners, directors of school support, principals, and teachers
    - Monitored data and progress, reporting directly to the superintendent
    - Attended quarterly national meetings, collaborating with other iLead partners across the country
    - Taught improvement science process to 26 district leaders from multiple departments
- Wrote and received grants for PRIME Math pilot course and follow-up grant, cocoordinated summer learning grants with university partners from USI, Ball State, and Purdue
- Collaboration with Evansville Public Libraries to implement a free online tutoring service for students in grades 3–12 in all core areas, including AP courses, SAT, and GED

Core Instructional Leadership

- Serve on the cross-functional Coaching Framework Steering Committee (2021–22) to reimage systemic coaching; subcommittee leader for continuous improvement cycles in a coaching context
- Collaborate with Directors of School Support to develop school leaders' understanding and teachers' implementation of high-quality mathematics instruction aligning this work to school SIP priorities
- Share supervision of mathematics department chairs, including evaluations, coaching, department meetings for district alignment, collaborating with building principals
- Work with stakeholders in formulating policies and procedures related to mathematics education
- Participate in the interviewing process for positions in mathematics K-12
- Collaborate with directors in the Office of Academic Affairs and the Office of Performance and Research to improve student outcomes
- Coconducted School Readiness Assessments with other district leaders and provided the following steps to individual schools

Curriculum Leadership

- Research and implement a vertically aligned high-quality mathematics curriculum (see partnership information)
- Prepared and update curriculum maps with essential information aligned to IDOE and Indiana Code and resources to supplement instruction
- Researched and purchased summer school math curriculum, wrote, and implemented pre/posttests aligned to the curriculum, data showed growth across classrooms that implemented the curriculum through pre/posttests and NWEA
- Wrote, analyzed, adapted, and facilitated writing sessions for aligned assessments for grades K-8 and High School Courses: Algebra I-PreCalculus
- Research best practices and provide staff development opportunities for teachers and building leaders for classroom implementation

- Analyze data from standardized formative and summative testing and facilitate adjustment of curriculum and instruction as needed
- Collaborate with Operations to ensure students and teachers receive curricular resources

LEAD INSTRUCTIONAL COACH | MCGARY MIDDLE SCHOOL | 2014–2016

- Responsible for research, creation, and implementation of all job-embedded professional development in the building
- Monitored goal setting, activities, classroom follow-up, and goal attainment for all departments. Assessed teacher evaluation results and maintained inter-rater reliability
- Developed and provided professional development for research-based strategies that supported student achievement in the identified areas of student need, as revealed from the analysis of data
- In-depth data analysis in English language arts, math, science, social studies, culture, and climate
- Coached teachers in areas of need as determined through walkthrough and support data or as requested by building administrators, including culture/climate, instructional best practices, and content best practices
- Conducted classroom observations and postconferences through iObservation
- Provided support to career teachers through observations and feedback, model teaching, and team teaching
- Worked with district strategist, data coach, and subject area coaches in the building
- Collaborated with Mass Insight Education and Research partners

TAP (Teacher Advancement Program) MASTER TEACHER | MCGARY MIDDLE SCHOOL | 2011–2014

- Collaborated with Mass Insight Education and Research partners
- National Institute for Excellence in Teaching (NIET) nationally certified evaluator
- Responsible for the overall system implementation. Monitor goal setting, activities, classroom follow-up, and goal attainment for cluster groups. Assess teacher evaluation results and maintain inter-rater reliability
- Research, field test, and provide professional development for research-based strategies to support student achievement in the identified areas of student need as revealed from the data analysis. (Problem-solving and conceptual understanding in mathematics, constructed response, assessment, vocabulary development, thinking, text-based questioning, and annotations)
- In-depth data analysis in math and English language arts
- Planned and implemented professional development for teachers with master and mentor teachers, led or co-led cluster meetings each week, Assessed all cluster group progress toward goals utilizing student data
- Conducted classroom TAP evaluations and conferences for both formal and informal TAP observations
- Provided support to career teachers as it relates to cluster learning, including observations and feedback, model teaching, and team teaching

MATH INSTRUCTIONAL COACH | MCGARY MIDDLE SCHOOL | 2010–2011

- Provided district-level professional development in many areas, including instructional best practices, classroom management, and creating a positive culture with diverse populations
- Provided building-level professional development in many areas, including the district data dashboard, assessment for learning, and Acuity
- Supported classroom teachers through modeling, team teaching, and observations and feedback
- Assisted teachers in the one-to-one netbook initiative implementation
- Principal Designee

SPECIAL EDUCATION TEACHER | NORTH HIGH SCHOOL | 1990–2010

- Indiana University Inclusion Course
    - Specially selected by the Director of Special Education to teach the IU inclusion course for EVSC
    - Taught basics of inclusion and its various structures, differentiated instruction, and best practices in
      the inclusive setting, and the collaboration of personnel.
- Highly qualified in the areas of math and English
- Coordinator of students' education through effective written and oral communication with parents, teachers, counselors, and administrators
- Knowledgeable in the laws of special education and the rights of special needs students
- Experienced in the inclusive setting and roles and responsibilities of inclusion teachers
- Committees: P.L. 221, responsibilities included sharing expertise in the field of special education, writing and refining school goals; offering ideas for improvement in the implementation of the plan; Positive Behavior Supports; Professional Development—4 years including one year as chairperson, responsibilities included establishing a plan for each year and presenting information on differentiated instruction to entire faculty, part of PD study group to help create PD plan specific to North; Safe Schools—chairperson 19 years, functioned as a facilitator to revise plan of action, communicator of an action plan to administrators and teachers, worked cooperatively with the director of school safety and assistant principal dean.

SPECIAL EDUCATION TEACHER | DEACONESS HOSPITAL (SATELITE CLASSROOM) | 1989–90

- Oversaw education of adolescents with emotional disabilities
- Communicated with teachers and counselors from home schools and hospital staff, including psychiatrists, psychologists, social workers, nurses, and techs, regarding the educational progress of resident students
- Assisted with the intervention of behavioral issues of students in the unit

Higher Education Experience

ADJUNCT FACULTY | UNIVERSITY OF SOUTHERN INDIANA | EVANSVILLE, IN | 2012–2014

- Taught EDUC 412-512: Assessment in Special Education to both graduate and undergraduate students
- Designed curriculum for the entire course
- Course objectives focused on the MTSS process, understanding state standards, designing assessments, and communicating academic success and needs to families, collaborative processes in schools.

INSTRUCTOR | PERFORMANCE LEARNING SYSTEMS | CADIZ, KY | 1994–2010

- Served as a facilitator of accredited graduate-level courses that Performance Learning Systems offers through Indiana Wesleyan University, Marion, IN
- Marketed courses throughout the state
- Coordinated with other instructors throughout the state of Indiana
- Courses taught: Project T.E.A.C.H.—a course focused on communication techniques with students and various other stakeholders in the educational setting; Differentiated Instruction—course includes a framework for DI as well as researched-based methods to initiate and sustain a

differentiated classroom properly; Teaching Through Learning Channels—course consists of research-based instruction in and application of perceptual, organizational, and temperament styles as well as preferred methods for learning new information; Cooperative Learning—the course contains a research-based system for properly using cooperative learning in the classroom; Live Event Learning—course introduces research-based techniques for using real-life activities and scenarios to teach standards.

Awards

2022 **EVSC/EVPL Free Tutoring Program Project or Program Award**
27th Annual Celebration of Leadership; Leadership Everyone
(Accepted on behalf of EVSC as project coordinator)

2019 **Dean F. Berkley Emerging Leadership Award**
Indiana University School Administrators Alumni

Professional Organizations

Association for Supervision and Curriculum Development
National Council for Teachers of Mathematics

Additional Training Experiences:

National Council for Teachers of Mathematics Regional Conference |2022| Indianapolis, IN

PLC+ Certification Training | 2022 | Virtual

National Council for Teachers of Mathematics National Conference | 2019 | San Diego, CA

Carnegie Foundation Summit on Improvement | 2019 | San Francisco, CA

IU Education Law and Policy Institute | 2019 | Bloomington, IN

Carnegie Foundation Summit on Improvement | 2018 | San Francisco, CA

IU Education Law and Policy Institute | 2018 | Bloomington, IN

Mathematics in a PLC Conference, District Administrator Strand | 2017 | San Diego, CA

National Council for Teachers of Mathematics Regional Conference | 2017 | Orlando, FL

Kagan Cooperative Learning Workshop Training | 2017 | Evansville, IN

IU Education Law and Policy Institute | 2017 | Bloomington, IN

Math Leadership Training, Butler University, Ryan Flessner | 2016–17 | Indianapolis, IN

Indiana Council for Teachers of Mathematics State Conference | 2016 | Indianapolis, IN

Leadership NOW Summit, Solution Tree | 2015 | Las Vegas, NV

IU Education Law and Policy Institute | 2015 | Bloomington, IN

Common Core Language Arts in a PLC at Work | 2015 | San Diego, CA

Teaching with Poverty in Mind Conference, Eric Jensen, Presenter | 2014 | Charlotte, NC

National Council for Teachers of Mathematics National Conference | 2014 | New Orleans, LA

Teaching and Assessing Mathematics in a PLC at Work Conference | 2013 | Lincolnshire, IL

Professional Learning Communities at Work National Conference | 2013 | Phoenix, AZ

National Institute for Excellence in Teaching, Teacher Advancement Program | 2013 | Washington, DC

National Institute for Excellence in Teaching, Teacher Advancement Program | 2012 | Los Angeles, CA

Teacher Advancement Program Summer Training Institute | 2012 | Indianapolis, IN

Brown University, Learning Leadership Cadre including Summer Leadership Retreat | 2011–12 | Providence, RI

Teacher Advancement Program Summer Core Training Institute | 2011 | Indianapolis, IN