Examining Instructional Reform Capacity for Teachers' Science and Mathematics Instructional Practices in Elementary Schools

by

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ABSTRACT

Efforts to improve student learning in K-12 education in the US are not new; however, educational research has traditionally focused on individual components of schools (e.g., teacher professional development, leadership, social relationships, programs, curricula) targeting teachers to improve student learning. While these innovations provide hope for change, they are limited in their focus and application to other school settings in that school contexts are unique to the individuals making them up and the collaborative missions and goals they pursue. To foster capacity for teachers to implement instructional reforms (i.e., how teachers teach), research must be focused on a holistic interpretation of the school as an organization. This study developed and validated a survey to examine elementary teachers' science and mathematics instructional practice use as well as their perceptions of instructional reform capacity within their school environment from an ecological organization perspective. Over 300 elementary teachers from a large urban district participated in the survey over the course of four weeks. Findings indicated elementary teachers utilized teacher-centered instructional practices more frequently than reform-oriented (i.e., student-centered) instructional practices. However, teachers reported more frequent use of instructional practices in their mathematics lessons compared to science lessons. Furthermore, data was used to investigate the underlying dimensions of instructional reform capacity and examine the relationship between those dimensions and instructional practice use both within and between subjects (i.e., science and mathematics). Results revealed dimensions underlying instructional reform capacity as well as correlations with instructional practice use are not the same for elementary science and mathematics. Dimensions of professional learning, structure, and policy were more strongly correlated with reform-oriented (i.e., student-centered) instructional practices. Implications from these findings suggest the necessity of a more holistic perspective of instructional reform capacity to better support instructional reforms across subject areas in schools, on both the local level and within research.

DEDICATION

This work is dedicated to:

My husband, Brian, for always pushing me to pursue my dreams and be my best.

Without your love and support, this would not have been possible.

and

My sons, Aiden and Andrew, for always reminding me of the important things in life.

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TABLE OF CONTENTS

CHAPTER Page

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Instructional reform in science and mathematics in the United States using content standards to guide instructional practices and student learning have been at the forefront of policies and positions held by organizations including the National Science Teachers Association (NSTA), National Council of Teachers of Mathematics (NCTM), National Governors Association, National Research Council (NRC), and Council of Chief State School Officers (CCSSO) (NCTM, 2000; NRC, 2012a; NGSS Lead States, 2013). The implementation of current content standards requires teachers to be deeply knowledgeable in content areas as well as have the ability to facilitate subject expertise into their teaching and student discourse (Ball et al., 2008). Advocated instructional practices are more aligned with student-centered, active learning practices as opposed to teacher-centered, lecture-based practices. The enactment of these reform-oriented techniques requires a shift in the beliefs, attitudes, and practices of most teachers (Hopkins, 2016). However, shifts in teachers' instructional strategies are not solely dependent upon the teacher's knowledge and their ability to facilitate student learning. The context in which they teach (i.e., schools) have prominent organizational structures. The interconnected nature of teachers and the context in which they teach has implications for the implementation of current content standards and instructional reforms supporting their implementation.

Statement of the Problem

Gaining momentum with the publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983), standards-based reform efforts linking content standards, curriculum, professional development, and assessments have become a key lever for local, state, and federal education agencies to influence instructional reform. Federal legislation and grants including No Child Left Behind (NCLB), Race to the Top (RTT), and Every Student Succeeds Act (ESSA) utilized predominantly top-down approaches including content standards and assessment adoption to spur systemic reform and improve teaching and learning for all students (ESSA, 2015; NCLB Act of 2001, 2002). Current content standards are the result of over 20 years of educational research and focus on student-centered instructional approaches and aligned accountability measures to improve student learning in the United States (NCTM, 2000; NGSS Lead States, 2013). However, our educational systems are being confronted by a multiplicity of demands to improve teaching and learning. COVID-19 disrupted instruction for more than 50 million students nationwide (CCSSO, 2020). Failure to meet existing and future needs for student learning is predicted to have grave consequences on student learning as well as prolonged effects on student's future opportunities (Kuhfeld et al., 2020). An approach to understanding the context of teaching and learning from both an individual and collective perspective is necessary to inform decisions regarding funding and policies so that these needs can be met.

While implementation of content standards is meant to improve student learning, research focused on the effectiveness of educational reforms in achieving ambitious instructional goals depicts inconsistent results (Milbrey Wallin McLaughlin, 1987; Spillane, 2004). Teacher's content knowledge has been associated with higher levels of student achievement (Monk, 1994; Sadler et al., 2013). Research suggests teachers' pedagogical content knowledge, their content knowledge as well as their ability to use their content knowledge within their teaching, is essential in student learning (Hill et al., 2005). Additionally, sustained and aligned professional development for teachers is often used to increase student learning outcomes (Supovitz & Turner, 2000; Wright, 2019). However, research indicates teacher learning does not always transfer into student learning (Barrett-Tatum & Smith, 2018). These approaches to transforming teacher practices are incomplete in their scope in that they focus on individual teachers and do not account for characteristics of the organization in which teachers implement their instructional practices.

While teacher instruction is one of the primary influences of student learning in the classroom, the shifts being targeted by policies are influenced by the complexities present in the local context in which they are being implemented. When looking to understand change initiated by reforms, it is essential that we understand the context of teachers. In attempts to improve student learning by shifting teachers instructional practices, schools and districts have collected information on student achievement and teacher evaluation (Woulfin, 2018), promoted social networks of teachers (Coburn, 2001; Gallucci, 2003), and engaged instructional coaches (Coburn & Woulfin, 2012; Galey, 2016; Mangin, 2014). These policies and decisions made at the local level have typically focused on how to influence teachers in becoming more effective. Not all approaches intended to achieve instructional goals have been effective at the organizational level and studies indicate teachers take up and implement instructional changes at varying levels (Coburn, 2004). While this research sheds light onto levers that can change teachers' instructional practices, it does not acknowledge that the local context is determined by the unique collective of individuals making it up.

Educational organizations (e.g., schools, districts, state education agencies) must be able to shift to a multiplicity of instructional demands including those of students, parents, and society at large. Rather than looking at these approaches to reforms as top-down and bottom-up, these single-lever and multi-lever reforms are limited in their ability to influence organizational change and reform teacher practices across different contexts (Elmore, 2004; Fullan, 2007; Honig, 2006; Hopkins & Woulfin, 2015). While research on the individual is necessary to shed light onto what conditions are associated with shifts in teacher's instructional practices, research suggests contexts contribute significantly to the impact of interventions and initiatives. Research targeting the organization level can provide a more holistic view of the context in which teachers are trying to enact instructional reforms and the capacity present thereby highlighting the supports or constraints influencing the shift. In this way, examination of instructional reform capacity of the organization from the local perspective and its association with elementary teachers' instructional practices is needed to better inform educational leader's decisions for their local context.

Conceptual Framework

Research suggests teachers' instructional practices are influenced by many factors including their professional content knowledge, instructional leadership, and other characteristics of the workplace (Bae et al., 2019; Coburn, 2005; Hill et al., 2005; Honig, 2006; McNeill et al., 2018). However, research focused on single-levers or even a combination of levers is limited in its scope of understanding and impacting the shift of teachers' instructional practices. This study will examine teachers' instructional strategies as well as the instructional reform capacity of the school environment from an organizational perspective in order to examine the context-specific relationship between the two. The framework utilized in this study conceptualizes schools as an ecological organization consisting of a learning community of individuals with some level of instructional reform capacity influenced by characteristics of the school and local education agencies (LEAs) (i.e., districts and central offices) (Hayes et al., 2020; Mitchell & Sackney, 2011). This framework recognizes the role of dynamic interplay between individuals, resources, and processes present at a school in which any new component or individual in the organization can influence other components or individuals.

The School Environment from an Organizational Perspective

Although teachers play an essential role in the enactment of content standards, research suggests actions taken at either the school or districts play a significant role in standards-based reform indicating that learning must take place not just at the individual level but at the organizational level as well (Cohen & Hill, 2001; Spillane et al., 2002). Schools can be considered organizations consisting of nested units (e.g., classroom, school, district) each made up of individuals with varying levels of agency and authority contained within an increasingly complex institutionalized environment in which interpretation and decision-making are distributed while additionally being influenced by multiple channels (McLaughlin, 1990; NRC, 1996, 2002, 2012a; Odden, 1991; Spillane, Reiser, & Gomez, 2006). In this environment, the translation of standards, from state adoption to their implementation in the classroom, can deviate in many ways because it involves the interpretation by multiple individuals and groups, including district policymakers, school level leadership, and classroom teachers (Spillane, 2004, 2005).

Additionally, researchers suggest characteristics of infrastructure within schools and districts as being important for instructional improvement (Hopkins & Spillane, 2015; Spillane et al., 2011). However, change efforts solely focused on formal structures (e.g., grade levels in elementary schools) that coordinate and control the work being done reveal these to be rituals that have little influence on practice (Bidwell, 2006; Meyer & Rowan, 1977), or that when formal structures get corrupted, intentionally or unintentionally, making changes in instruction difficult (Firestone, 1985; Fuller, 2008). Schools must still work to figure out which combination of levers will address their needs and how to tailor their infrastructure to support those needs.

Organizations are considered by most researchers to be "social structures created by individuals to support the collaborative pursuit of collective goals" (Scott & Davis, 2007, p. 11). According to Scott and Davis (2007), organizations are composed of elements including the environment, strategy and goals, work and technology, formal organization, informal organization, and people. Scott and Davis (Scott & Davis, 2007a) present organizations as well as the process of organizing within them as being situated within one of three systems including a rational system, a natural system, or an open system. Open systems are "open to and dependent on flows of personnel, resources, and information from outside" (Scott & Davis, 2007a). Viewing organization as being open systems enables individuals to have multiple identities and loyalties as well as highlights the construction of the organization by cultural-cognitive elements. Possessing many of these same characteristics, schools and districts can be considered to be an open system from an organizational perspective.

Organizational Capacity for Instructional Reform

To attend to the complexity of the educational organization, Honig (2006) identified the intersection of the spheres of policy, place, and people as influencing education reform implementation. Drawing on sociocultural and organizational theories, Honig (2008) proposed a conceptual framework including practices and processes that might be present if district offices operated as learning organizations. Although there are complementary components of sociocultural and organizational learning theories present in this framework, there are limitations as well. Scholars using sociocultural and organizational theories have been unable to find common ground upon which the theories are able to complement one another. Differences between the fields include what counts as learning and whether organizations can learn. A lack of agreement across underlying assumptions or concepts involved in frameworks makes drawing conclusions from Honig's findings complicated.

While Honig's interpretation of the spheres lends itself to a more holistic understanding of the organization in which instructional reforms are taking place, there are difficulties with the conflicting underlying theories which makes its ability to inform educational leaders at the local level problematic. On the other hand, research has suggested capacity building facilitates curriculum or policy implementation (Hatch, 2013; Malen, 2006; Spillane et al., 2011). Framing research from the perspective of organizational capacity can promote a more context-centric perspective of instructional reform. The model of organizational capacity centralizes a core instructional capacity existing within an environment that supports it (Hatch, 2013). The environment consists of different types of capitals (e.g., human, social, and financial) relevant to instructional reform and interacting across different levels (Spillane & Thompson, 1997). Mitchell and Sackney (2011) present an ecologically nested model of instructional reform capacity. Hayes and Bae (2016) modify this framework drawing from the sociological theory of capitals (Coleman, 1988) and engage five dimensions (*expertise*, *cultural*, *social*, *structural*, and *policy*) of the context. This framework, situated in the literature, provides an opportunity for researchers to understand the more context-dependent process of educational reform.

Purpose of Study

Educational leaders need to be able to make informed decisions regarding policies and initiatives in order to have the best chance of supporting instructional reforms. As such, they need access to data framed by current research and customized for their local context. However, policies and initiatives at the federal and state level lead to data that is too coarse-grained to reveal the context and influence of local agents (e.g., teachers and administrators) in instructional reform engaging standards implementation. Reliance on big data to make decisions for local contexts inherently devalues the uniqueness of the individuals engaging within the context including their experiences, culture, and social interactions. Therefore, while key components (i.e., levers) of instructional change from nationally administered surveys and published books outside of the research community may provide insight for educational leaders, they are not necessarily effective for their particular context.

Qualitative research in education policy implementation has shown that context plays an essential role in whether reform initiatives are taken up by teachers and translated into their teaching. Much of the research engaging in instructional reform emanates from single or comparative case study research designs. While informative, this approach to understanding implementation of instructional reform limits the ability to draw conclusions about how typical or prevalent the patterns of implementation are across schools, districts, or even states. While case studies provide insight into the local context and interactions between teachers within the learning environment, they lack the power to be able to inform or influence broader policy and initiative decisions to be made by educational leaders. With the amount of research engaging educational reforms and their impact on instructional practices completed since the inception of standards-based reform, there exists enough research supporting the creation of a survey measuring the constructs within an education organization found to be salient in the effectiveness of changes in teachers' instructional practices. Within this study, such a survey will be designed to assess the presence of instructional practices of elementary science and mathematics with respect to their organizational context utilizing current research in instructional reform capacity and customized to the local context of Arizona.

In addition to mounting evidence supporting research on capacity from a holistic perspective, there is a need to understand differences, if they exist, between subject areas in schools. Much of the existing research focuses on either single subject areas or on subjects aligned with state-level policies resulting in a lack of comparison across subject areas and a deficit in certain subject areas. Research designed to examine similarities and differences in teachers' approaches to math and science instruction as well as understand the role of capacity in those similarities and differences is lacking. As schools look to support teacher and student learning, especially post pandemic, research engaging capacity from a holistic perspective and for multiple subject areas is essential to informing future research and providing information to educational leaders to make decisions for their local context.

While data collected at the local level does exist, it is limited to that required by state policies and initiatives. Data compiled at the local level including data relating to student achievement, professional development, and teacher evaluation provide insight into the local context; however, these data represent individual levers of a more complex organization and tend to focus on subjects required by instructional reform policies. Furthermore, these data do not capture the intermediate changes and shifts needing to take place prior to changes in later outcome measures. Current data collected at the local level can capture shifts over longer periods of time but sudden pressures to the system can make understanding data from reforms even harder to see in the outcome data being collected. A survey examining the multiple dimensions of organizational capacity present within the organization and across subject areas can better inform the key components that are more associated with reform-oriented instructional practices. Therefore, the focus of this study is examining the relationship between elementary teachers' science and mathematics instructional practice use and their perceptions of instructional reform capacity present at their school. Consequently, the aim of this study is to provide educational leaders with a way to identify high leverage components to target funding and policy.

The purpose of the survey was two-fold (1) to identify the instructional practices elementary teachers utilize with respect to science and mathematics instruction, and (2) to identify the extent to which dimensions of the instructional reform capacity of a school are associated with elementary teachers' instructional practices, specifically for science and mathematics. With these purposes in mind, this study addressed the following research questions:

1. What instructional practices do elementary teachers engage most frequently and to what degree do these practices align with reform-oriented instructional practices promoted by national teacher organizations?
    a. In science instruction?
    b. In mathematics instruction?
    c. In science as compared to mathematics?
2. To what degree are the five dimensions of instructional reform capacity (*expertise*, *cultural*, *social*, *structural*, and *policy*) present at the organizational level associated with elementary teachers' use of reform-oriented instructional practices?
    a. In science instruction?
    b. In mathematics instruction?
    c. In science as compared to mathematics?

Significance of Study

This study provides an understanding of current elementary teachers' reported instructional practice use in science and mathematics lessons. Given the instructional reforms inherent in the current content standards for science and mathematics and the time required for shifts to take place in instructional practices, it is likely that teachers' instructional practices are shifting over time. This study provides information to educational leaders regarding the current state of teachers' perceptions of their instructional practices. Since teacher's beliefs of their own instructional practices are influential in their uptake of instructional reform, this information can inform educational leaders' decisions regarding funding and policies for continued instructional reform.

Additionally, this study contributes to the existing literature on capacity for instructional reform. In this study, capitals are used to encapsulate the underlying elements of capacity to understand if, and how, these elements interact with instructional reforms for science and mathematics. Treating capacity from an ecological constructivist framework, rather than as a monolithic entity, provides insight into the dynamic interplay of elements and allows for differences across subject areas and schools. Not only can this framework provide a more comprehensive understanding of capacity within the literature but it can also help support schools in their efforts of instructional reform by providing them with intermediate measures of change respective of their specific context (e.g., students, faculty, families). As we come to recognize and support the diversity of learning taking place in our schools, the ecological constructivist perspective of capacity for instructional reform within schools is essential to supporting these efforts.

Furthermore, this study adds to the existing literature by examining the relationship between elementary teachers' instructional practice use and capacity of the organizational context (i.e., the school) in which they teach. In light of the diversity of demands on the educational system and the ongoing implementation of current science and mathematics content standards in Arizona, research conducted to understand the relationship between the context and elementary teachers' instructional practices is essential. The development and validation of a survey based on an ecological constructivist framework can highlight what elements of capacity are necessary for reform-oriented instructional practices enabling educational leaders to make informed decisions targeting funding and policy specifically aligned to the needs of their teachers with respect to their local context.

CHAPTER 2

LITERATURE REVIEW

As society has changed over time, teachers and the schools they teach in have had to shift to changing needs and desired goals. While the primary goal of schools has always been student learning, what it means, how it takes place, and how it is measured fluctuates. There have been pendular shifts in objectives from what is necessary for citizens to know and be able to do to higher level content standards. Policies have changed their objectives from minimal competency assessments to top-down accountability and assessment practices. Promoted instructional practices have changed from teacher-centered and lecture-based to student-centered and activity- or inquiry-based. Reform efforts have tried to improve educational opportunities, making them more equitable to all students in the diverse context of schools. Our most recent experience of a global pandemic has brought yet further pressures for shifts and changes for teachers and schools. This study aims to assess the elementary teachers use of reform-oriented instructional practices for science and mathematics as well as their relationship with teachers' perception of instructional reform capacity of schools to undertake and support reform-oriented instructional practices.

Within this chapter, I first provide an overview of reform-oriented instructional practices, specifically related to science and mathematics, followed by a review of the major factors influencing implementation of reform-oriented teaching practices including the sudden pressures caused by the coronavirus pandemic of 2020. Next, I will present the theoretical foundation upon which the conceptual framework for this study is based. Finally, I will present the instructional reform capacity framework being used for this study. Collectively, this review of the literature establishes the need for empirical data to examine elementary teachers' use of reform-oriented teaching practices and to understand the association between their teaching practices and their perceptions of the organizational capacity of their context for instructional reform implementation.

Instructional Reform in Elementary Science and Mathematics

The time period from 1945 to the late 1970s, encompassing major national and global events including multiple wars and the Civil Rights movement, became a platform for the federal government to promote a shift of the role of schooling from practical preparation to one promoting high quality science and mathematics instruction (Barrow, 2013). Following this time, studies to better understand student achievement became prevalent after federal grants were distributed to assist with this shift to higher learning standards for all students. Reports from these studies conveyed an imperiled perspective of American technological and economic dominance citing a downward trend of student performance on internationally benchmarked tests and average achievement on most standardized tests being lower than it had been in 1957 (National Commission on Excellence in Education, 1983). Although later analysis that accounted for subgroups within the expanding student enrollment would later contradict these findings (Guthrie & Springer, 2004), the movement towards assessing schools and teachers based on students' outcomes was initiated by these publications.

In addition to other top-down school reforms including increased graduation requirements, time for instruction, and competency testing, this movement promoted implementation of state-standardized curriculum including subject specific instructional objectives for grade bands (Blosser, 1984; Medrich et al., 1992). Although not research-based, the development of content standards at the state level engaged a diversity of stakeholders including the work of organizations such as the National Science Teaching Association (NSTA), American Association for the Advancement of Science (AAAS), and National Council of Teachers of Mathematics (NCTM).

Guiding the development of science objectives was Project 2061: Education for a Changing Future, a long-term, multi-phase effort by the AAAS, designed to achieve scientific literacy in the United States. *Science for All Americans* (AAAS, 1990), compiled voices not just from educators but also scientists, engineers, historians, and mathematicians, providing of a set of recommendations aimed to improve the rigor of science education by emphasizing the (1) interdependence of science, mathematics, and technology; (2) key concepts and principles within science; (3) unity and diversity of the natural world; and (4) use of scientific knowledge and ways of thinking (AAAS, 1995).

On the mathematics side, a working group, comprised mostly of university level teacher education instructors and professors, developed the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) containing general standards for grade bands as well as evaluation standards. This document promoted (1) greater attention to certain topics (e.g., meanings of operations, mental computation) with decreased attention to others (e.g., long division, rote practice, etc.), (2) use of calculators across grade levels, and (3) progressive approaches to instruction (i.e., student-centered, discovery learning) (Klein, 2003). Reforms of this time were not research-based but rather a call for higher education standards advocated by a select set of voices from those in positions outside K-12 education in order to improve student outcomes.

With more than 20 years of educational research focused on content standards implementation as well as teaching and learning, research-based recommendations for use in elementary science and mathematics have evolved. As a result, a second generation of content standards (e.g., Next Generation Science Standards [NGSS] and Common Core State Standards [CCSS]) recommended particular instructional strategies considered reform-based teaching (NCTM, 2014; NRC, 2012; NGSS Lead States, 2013).

The National Research Council (NRC) report *Taking Science to School* (2007) conveys science proficiency as multifaceted requiring a range of experiences. It recommends experiences engaging students within and between four strands of proficiency to promote science learning including:

1. Knowing, using, and interpreting scientific explanations of the natural world.
2. Generating and evaluating scientific evidence and explanations
3. Understanding the nature and development of scientific knowledge.
4. Participating productively in scientific practices and discourse.

Some of the instructional strategies that provide students with these experiences include providing time for inquiry and investigation, enabling collection and analysis of evidence, promoting logical reasoning, and prompting communication and application of information (NRC, 2010).

Within mathematics and according to the NCTM (2014, p. 10), teaching practices meant to strengthen student learning of mathematics include the following:

1. Establish mathematics goals to focus learning
2. Implement tasks that promote reasoning and problem solving
3. Use and connect mathematical representations

4. Facilitate meaningful mathematical discourse
5. Pose purposeful questions
6. Build procedural fluency from conceptual understanding
7. Support productive struggle in learning mathematics
8. Elicit and use evidence of student thinking

Instructional practices that are more student-centered and activity-based have had more of an impact on student learning as opposed to the instructional outcomes originally introduced and traditionally more teacher-centered and lecture-driven (Bryk, 2010).

Factors Influencing Implementation of Reform-oriented Teaching

The current standards-based reforms focus on reform-oriented instructional practices meant to improve student learning in the United States (NCTM, 2014; NRC, 2012). In the years since reform-oriented teaching was initially promoted, educational research continues to identify and search for components, or levers, of the educational setting that are influential in shifting the instructional practices implemented by teachers. With the goal of equity for all students, it is essential that research aim to understand the implementation process of reform-oriented instructional strategies across the complex educational context in which they are enacted. Honig's (2006) presentation of research as being representative of the spheres of people, place, and policy emphasized a more integrated and complex view of implementation. While this view of implementation is still limited in its scope, this literature review is going to use these spheres to present the findings of research. Although all actors play a role in the interpretation and enactment of reform-oriented instructional practices, this review of the literature emphasizes research identifying attributes of the school or local education agency (LEA). Research suggests context plays an influential role in the implementation of content standards aligned with reform-oriented instructional practices (Cohen & Hill, 2001; Spillane et al., 2002).

Attributes of People

When it comes to student learning, teachers play a very significant role. The ability of teachers to enact reform-oriented instructional practices in alignment with research-based content standards is dependent upon their knowledge and skills. While teacher preparation programs play a significant role in development of the knowledge and skills of pre-service teachers, being a teacher requires a life-long commitment to continued learning and skill development (Lannin et al., 2013). Research indicates one of the influential ways to improve instructional practice as well as the academic success of students in classrooms is professional development for teachers (NCTM, 2014; NRC, 2012). Professional development should be ongoing, rich in content knowledge, closely linked to teachers' classroom practices and needs (Supovitz & Turner, 2000). Positions including department chairs, instructional specialists, or coaches distribute the role of instructional leadership and typically take on responsibilities of leading professional development of educators (CCSSO, 2016; Galey, 2016). In some cases these positions exist without clear expectations, necessary training, or formal qualifications of those who fill those positions (Laxton, 2016; Martinez, 2019).

In addition to supporting the implementation of reform-oriented teaching practices, individual characteristics can also hinder their implementation. First, individuals have been observed forming analogies and connections between their current understandings and the new knowledge of the educational reform. This can lead to misinterpretation or the perception of reform ideas as more familiar than they are meant to be (Spillane, 2000, 2004, 2005). Second, the prior knowledge, beliefs, and values of an individual can lead to different interpretations or misunderstandings of educational reforms resulting in superficial implementation (Spillane et al., 2006). Additionally, agency and authority of decision makers can influence opportunities for professional development (Barrett-Tatum & Smith, 2018) and length of exposure (CCSSO, 2016; de los Santos, 2017; Spillane et al., 2002) which influence capacity and sensemaking of individuals enacting educational reforms (Loveland, 2004).

As Spillane (1998) points out, school and LEAs can be interpreted as a compilation of socially constructed knowledge of the individuals making it up. In addition to individual cognition, research suggests implementation can be influenced by social interactions between and among individuals including formal and informal networks (Coburn, 2001), professional learning communities (Porter et al., 2015), and coaching (Woulfin, 2018). Affordances to implementation have been shown to be achieved through mutual cognitive adaptation of the standards including the inclusion of teachers in the implementation process (Bianchini & Kelly, 2003). Although implementation of reform-oriented instructional practices may be considered a political undertaking (Werts & Brewer, 2015), research has shown that even with changing political environments and inconsistent leadership, iterative engagement including individuals across levels can result in joint construction of policies enabling success despite an inconsistent environment (Chrispeels, 1997). In some cases, the strength of social communities can hamper implementation by enabling nonaligned policies to be enacted (Gallucci, 2003). Sensemaking, whether it be individual or collective, about content standards implementation can influence the way individuals implement content standards. Social relationships and networks within which individuals engage play a role in their interpretation and interaction with the educational reform (Coburn, 2001; Datnow, 2012; Finnigan & Daly, 2012).

Attributes of Policy

Gaining momentum with the publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983), policies engaging instructional reforms (e.g., content standards) have become a key lever for state education agencies to influence education reform. Federal legislation including No Child Left Behind (NCLB) and Every Student Succeeds Act (ESSA) have utilized a predominantly top-down approach to influence states in their adoption and implementation of content standards and aligned reform-oriented instructional strategies to increase learning for all students. Although the policy development process of content standards can include much negotiation and bargaining, it is not likely to engage all individuals or organizations responsible for interpretation or implementation. Therefore, policy characteristics such as design, instruments, as well as supplemental documents can shape the interpretation and influence enactment of the content standards as they travel from the statehouse to the school house.

In order for content standards policies to be effective in complex school environments, their design must clearly convey the goal of the policy, identify and involve implementors, and involve instruments for implementation (Honig, 2006). Tight timelines of attaining or adjusting to goals can overwhelm the process and hinder implementation (CCSSO, 2016; Fullan, 2007). In a study of the Common Core State Standards (CCSS) implementation in North Carolina, Porter et al. (2015) found the fast pace of implementation constrained teacher's implementation by requiring a lot of learning in a limited time period, thereby undermining effective implementation. Early exposure and sustained engagement of teachers can support implementation but can also be impacted by the prescribed timeline of policy goals (Chrispeels, 1997). The ability for content standards to clearly communicate goals and engage individuals, both internal and external to the organization, plays an significant role in the subsequent alignment of local policies including curriculum, instruction, and assessments (Honig, 2006; Young & Lewis, 2015).

In addition to goals, policies utilize instruments that must be adaptable to the changing conditions within and outside the system itself to achieve implementation (McDonnell, 1994; McDonnell & Elmore, 1987; Schneider & Ingram, 1990). Considering instruments to be the mechanisms by which policy goals are translated into tangible actions, McDonnell and Elmore (1987) classified instruments according to their underlying assumptions of influence into the four categories of mandates, inducements, capacity-building, and system-changing. For example, Spillane (2005) found the mandate of student performance on a statewide assessment being linked to school accreditation as a key motivator of mathematics and science standards implementation in Michigan in the early 2000s. Alternatives to the top-down instruments (i.e., mandates and inducements) strive to influence implementation by changing the system or building capacity. These approaches can offer more flexibility for interpretation and implementation while also providing pressure. In policymaking, school districts utilize some of these alternative instruments to promote alignment and coherence while also building organizational resources and capabilities. Research shows that districts target professional development, assessment, and curriculum as instruments to align expectations between the standards and the technical environment (Bianchini & Kelly, 2003; Coleman et al., 2012). The degree of content standards implementation can be influenced by the incorporation and alignment of policy instruments at both the state and district levels targeting the technical environment of the classroom.

As content standards traverse the nested hierarchical structure of the school system from the state to the classroom, school districts create local documents framing interpretation and conveying recommended actions for successful implementation (Honig, 2006; Spillane, 2005). In a study of mathematics and science standards implementation, Spillane (2004, 2005) found only one-third of districts created and supported policies going beyond superficial topic coverage and sequencing. Contrastingly, districts creating documents through an interactive policymaking process provided stronger support for epistemological changes resulted in a deeper understanding of reform ideas across the hierarchical structure. With a lack of policy documents supporting deeper understanding of the epistemological intent of the content standards, the intent of fundamental change to instruction from the standards was not realized in the districts that did not create documents.

Attributes of Place

While individual characteristics have been shown to moderate and influence the implementation of reform-oriented teaching practices aligned with current content standards (Honig, 2006; Odden, 1991; Werts & Brewer, 2015; Young & Lewis, 2015), characteristics of the school or LEA can influence overall implementation. Although there are a multitude of characteristics comprising place, this review focuses on technical, structural, cultural, and social resources which research suggests are integral factors influencing the depth of understanding and enactment of instructional practices aligned with content standards (Gao et al., 2018; Honig, 2006; Spillane, 2005).

Compared to the state, districts not only have more funding with which to support the technical and structural resource needs (e.g., time, staffing, curriculum, laboratory and classroom space, as well as related equipment) of reform-oriented instructional practices but also have more deciding power of allocating those funds and thus are a significant influencer in the extent to which implementation can occur (Berman & McLaughlin, 1977; Porter et al., 2015; Spillane, 2004). Spillane (2004, 2005) found time for investment in instructional reforms differed depending upon size of the school district, with small school districts having less time for investment in instructional reforms. Research of early implementing states of the Common Core State Standards found a lack of available curricular resources prompted the need to create their own (CCSSO, 2016). In findings from a survey of 584 K-12 school districts across 48 states and the District of Columbia, Allen and Seaman (2017) reported that over 75% of the districts adopted a new full-course curriculum to meet the needs of changing content standards and instructional practices. In addition to curriculum, science standards implementation requires laboratory space and supplies which can further strain their implementation in all communities (Ceballos, 2012; Gao et al., 2018; Urick et al., 2018).

The culture of the place in which implementation is taking place has also been shown to have an impact on the implementation process itself. Routines including communication of information regarding instructional reforms can impact the fidelity of implementation (Porter et al., 2015). Over time, the pattern of decision-making can establish a history that can influence district policymakers sensemaking of instructional reforms (Spillane, 2005). Implementation can be challenged when the norms and routines that must be implemented are inconsistent with the grammar of schooling (Tyack & Tobin, 1994). Additionally, expectations, priorities, and decisions from leadership help to establish the culture influencing instructional approaches, interactions, and program offerings (NRC, 2012b). Research suggests commitment and support of leadership is essential to initiating and sustaining educational innovations (Fullan, 2007; Marshall, 2018; McLaughlin, 1990; Spillane, 2004).

Even if other resources are supportive of implementation, the opportunities for social interaction amongst individuals engaging with the resources is essential for individuals to make sense of the reform as well as create a cohesive plan for implementation (Spillane, 1999). Prior to the most recent versions of both math and science standards, the Education Commission of the States recommended the use of reform networks, defined as interconnected groups of educators, schools, or districts with a common interest in a specific reform approach, in order to strengthen the capacity of schools and districts to undertake and sustain reform (Education Commission of the States, 1997). In many cases, the place designates the structure as well as controls the opportunities for individuals to engage in this process of organizational learning.

Social resources have been shown to be able to promote as well as hinder implementation depending upon the individuals present in the network. In an exploration of the relationship between teachers' social networks and the sustainability of reform efforts, Coburn et al. (2012) found social networks consisting of strong ties, high-quality interactions, and high levels of expertise were influential to sustainability if they were in place for the first two years of implementation. The structure and activities of social networks were also shown to influence the ability of the network to play a boundary-spanning role across levels of actors and support implementation of the Common Core in New York City (Wohlstetter et al., 2015). While relationships can engage individuals within the immediate organization, they can also influence implementation by engaging individuals or organizations external to the organization (e.g., professional networks, parents, and experts including consulting firms and universities) (Coburn, 2006; McLaughlin, 1990; Spillane, 1999). For example, findings from a survey of 584 K-12 school districts in 48 states and the District of Columbia found the textbook adoption process to be typically collaborative, engaging multiple stakeholders including teachers, principals, district administrators, outside experts, and parents (Allen & Seaman, 2017). Although collaboration can positively influence organizational learning, networks with limited connectivity can lack the support required of organizational learning (Datnow, 2012; Finnigan & Daly, 2012). Beyond the structure and activities of these networks, research indicates the presence of relational trust in relationships as being a key determinant in their effectiveness in promoting discussions focused on individual's interpretations or reservations about the standards (Spillane, 2004, 2005).

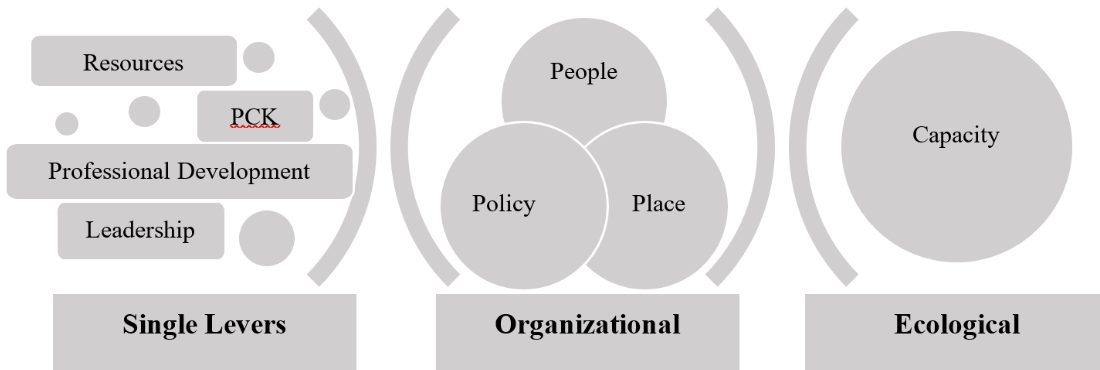
The coronavirus pandemic added more pressure to instructional reform with school closures and sudden transitions to virtual learning environments in the spring of 2020 affecting over 55 million students in 124,000 public and private schools across the United States (Peele et al., 2020). The predicted loss of student learning as well as the longer impacts on overall learning as schools either remained in a virtual environment or shifted to a virtual environment as required by state or local decisions has significant implications moving forward (Allen et al., 2020; Kuhfeld et al., 2020). Huge technology inequities were revealed including reliability and access to devices and the internet (Bushweller, 2020). As the 2020-2021 academic year started, schools offered various instructional models including in-person, virtual, or a combination of the two to prevent disruption to student learning. In an educational system where there were already concerns over inequities influencing student's opportunities to learn and the implementation of instructional reforms to reduce these inequities, there is further concern on how the pandemic is impacting teachers and student learning. A shortage of research regarding implementation of instructional reforms framing schools as organizations leaves educational leaders lacking knowledge of the resources and processes that can support instructional changes being demanded by our current situation.

Theoretical Framework

This study employs a theoretical foundation conceptualizing schools as part of an ecological or open organization having capacity to implement instructional reform. As the research has transitioned from being focused on single-levers (e.g., resources, pedagogical content knowledge (PCK), professional development, leadership) to a more complex model of interacting spheres of influence (e.g., people, policy, place). This study argues conceptualizing schools as ecological organizations having capacity composed of elements aligned with capitals that interact to influence instructional reforms (Figure 1). This conceptualization provides a more holistic view of the characteristics influencing teachers' self-reported use of reform-oriented instructional practices.

Figure 1

Shifting the Conceptualization of Implementation Research in Schools



The implementation of reform-oriented instructional practices in alignment with current science and mathematics content standards requires learning by those who are implementing them (Spillane & Thompson, 1997). As such, conceptualizing schools as ecological organizations composed of individuals having the capacity for learning and shifting instructional practices incorporates allows research to focus on the resources, processes, and individuals as a dynamic interaction. While Bronfenbrenner's initial focus is on development and learning of children, his theoretical focus on person-context relational processes as being embedded and dynamic across the system highlights the ability of individuals to influence the organizations they are a part of as much as those organizations influence them (Bronfenbrenner, 2005). His consideration of organizational levels being nested and not hierarchical while still being permeable accentuates the dynamic influence and learning between individuals and the context in which they interact. Effective implementation of reform-oriented instructional practices implies teachers with resources who are engaging in processes that allow them to reconstruct their knowledge, beliefs, and dispositions. As such, this study employs a theoretical foundation of capitals in order to understand the capacity of schools to undertake instructional reform.

Schools as Organizations

Classic organization theories are from economics and business, including Taylor's scientific management, Weber's bureaucratic approach, and Fayol's administrative management theory (Scott & Davis, 2007a; Taylor, 1911; Weber, 1968). Organizations are considered by most researchers to be "social structures created by individuals to support the collaborative pursuit of collective goals" (Scott & Davis, 2007, p. 11). According to Scott and Davis (2007), organizations are composed of elements including the environment, strategy and goals, work and technology, formal organization, informal organization, and people. Their prevalence within our society is due to their durability, reliability, and accountability. Scott and Davis (2007) present organizations as well as the process of organizing within them as being situated within one of three systems including a rational system, a natural system, or an open system. Rational and natural systems assume the organization, its processes for organizing, and its participants are contained within a closed system, separate from its environment. Contrastingly, organizations considered to be open systems are "open to and dependent on flows of personnel, resources, and information from outside" (Scott & Davis, 2007, p. 31). Viewing organization as being open systems enables individuals to have multiple identities and loyalties as well as highlights the construction of the organization by cultural-cognitive elements.

As you traverse the United States, schools and LEAs are broad in what they look like in that there is similarity of structure and function but they are all unique, in one way or another, in ways that work best for their community. As content standards aligned with instructional reform traverse the nested structure of the schools and LEAs from the state to the classroom, local policies are created, framing interpretation and conveying recommended actions for successful implementation (Honig, 2006; Spillane, 2004, 2005). Schools can be considered organizations consisting of nested units (e.g., district, school, classroom) each with varying levels of agency and authority contained within an increasingly complex environment in which interpretation and decision-making are distributed, while additionally being influenced by multiple channels (McLaughlin, 1990; National Research Council, 1996, 2002, 2012a; Odden, 1991; Spillane, Reiser, & Gomez, 2006).

Viewing schools and LEAs as an organization is a useful framework for researchers to understand the implementation of instructional reforms within its complex context (Peurach & Neumerski, 2015). The translation of standards, from state adoption, into reform-oriented instructional practices in the classroom can deviate in many ways because it involves the interpretation by multiple individuals and groups, including district policymakers, school level leadership, and classroom teachers (Spillane, 2004, 2005). Researchers suggest characteristics of infrastructure within districts and schools as being important for instructional improvement (Hopkins & Spillane, 2015; Spillane et al., 2011). However, efforts to change formal structures present these to be rituals having little influence on practice (Meyer & Rowan, 1977). Viewing schools and LEAs as an organization can help decision-makers understand which characteristics or combination of characteristics will address their needs and how to tailor their organization to support those needs.

Capacity

In order for schools to undertake a shift in instructional practices more aligned with reform-oriented teaching, the organization must support a sustained and interactive learning environment for teachers. Educational researchers have used the term *capacity* to describe the ability to support this type of environment (Spillane & Thompson, 1997). In their study of five districts, Spillane and Thompson found prominent features of capacity (i.e., knowledge, commitment, disposition, professional networks, trust, collaboration, time, staffing, labor, and materials) were present in those districts most successful in reforming instruction. These characteristics align with concepts of various forms of capital.

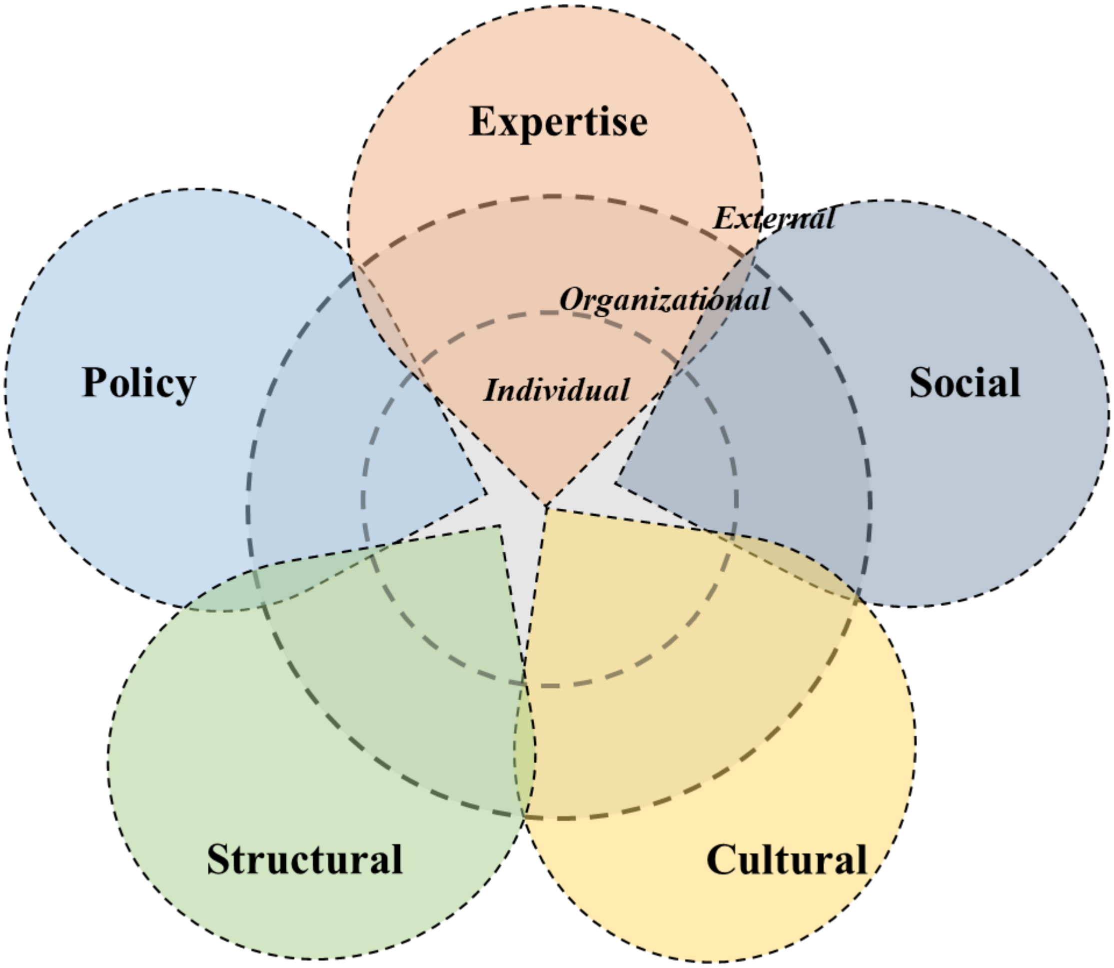
"Capital" refers to "relating to or being assets that add to the long-term net worth" according to Merriam-Webster (2015). Utilizing this definition of capital with regards to schools provides a foundation for understanding how resources work in the implementation of reform-oriented instructional practices. In this manner, capitals are "resources for action" (Coleman, 1988). Coleman (1988) described physical capital as "embodied in tools, machines, and other productive equipment", human capital as "changes in persons that bring about skills and capabilities that make them able to act in new ways", and social capital as "changes in the relations among persons that facilitate action" (Coleman, 1988, p. S100). Therefore, the dimensions of capacity can be viewed in terms of capitals with individuals making up the school as being socialized and acting within a structure of norms, rules, and obligations.

Conceptual Framework for Instructional Reform Capacity

To understand the relationship between elementary teachers' science and mathematics instructional practices and the characteristics of the organization within which they teach, a conceptual model must be utilized. This study uses an instructional reform capacity framework proposed by Hayes and Bae (2016) and adapted from that proposed by Mitchell and Sackney (2011). The instructional reform capacity framework incorporates a nested ecological nature of schools including three levels (i.e., individual, organizational, and external) with the five dimensions of capacity (i.e., *expertise*, *cultural*, *social*, *structural*, and *policy*) research has shown to influence instructional practices within schools and across districts (Figure 2). These five dimensions are thought to work interactively across multiple levels of the nested ecological structure of schools and LEAs (Hayes & Bae, 2016; Mitchell & Sackney, 2011). Conceptualizing instructional reform using this framework should permit the identification of the characteristics of organizational capacity associated with teachers' reform-oriented instructional practices.

Figure 2

Instructional Reform Capacity Framework

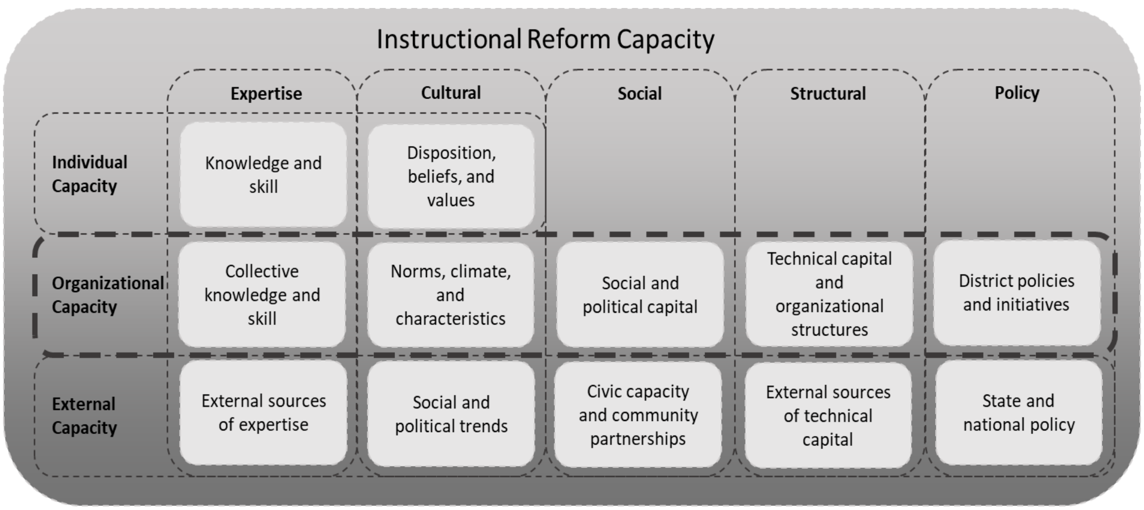


This approach to capacity develops from the foundation that capacity is the interplay between different types of capitals at different levels of an ecological system. Hayes & Bae (2016) described capacity as consisting of the "various resources available to the organization that can be acquired, held, or used to support organizational goals" (p. 6). This framework assumes teachers and administrators make up a learning community and they are a vehicle for professional learning and instructional development at the school level. Research has indicated that these five dimensions influence the capacity for teachers and educational leaders to be aware of, take up, and institute instructional reform (Cohen & Ball, 1999; Hayes et al., 2020; Mitchell & Sackney, 2011; Spillane & Thompson, 1997). Spillane and Thompson (1997) identified physical capital, human capital, and social capital as influencing the implementation of instructional reforms. Additionally, Cohen and Ball (1999) indicated that instructional capacity and the environment of instruction interacted with one another and influence the implementation of instructional reforms. Instructional capacity includes teacher expertise, student engagement, and instructional materials. The environment of instruction includes structure of schools, instructional leadership, norms, and society. The capacity of an organization to undergo reform successfully is not solely dependent upon the resources present but is also highly dependent upon how those resources are utilized and negotiated in order to be implemented into the working knowledge and practices of the individuals making up the organization.

The framework, proposed by Hayes and Bae (2016), being used in this this study is slightly different from Mitchell and Sackney's (2011) framework. First, while both conceptual frameworks identify three levels of the ecological system of schools, Mitchell and Sackney's framework identified the domains that enable the building of a learning community as personal, interpersonal, and organizational. While this does create a distinction between small group interactions among colleagues from the broader organizational context, it neglects the influence on a learning community from the external domain. Resources as well as opportunities to engage with these resources are not always from within the organization and sometimes interactions with external sources (e.g., university, professional organization, business, etc.) are necessary to achieve reforms (Spillane & Thompson, 1997). In addition to the domains, or levels, being utilized, Mitchell and Sackney used ecological theory. In contrast, the dimensions of the conceptual framework being used in this study are theoretically grounded in capitals and how they function (Figure 3). Additionally, the levels are aligned to an ecologically nested educational organization and are grounded in organizational theory.

Figure 3

Dimensions of Capacity within the Instructional Reform Capacity Framework (Hayes et al., 2020)



Individual Level

The individual level of the nested structure of schools involves the capacities individuals (e.g., teachers, leaders, and students) have gained over their lifetime and utilize within the specified setting. While, on the whole, the instructional capacity framework proposed by Mitchell and Sackney (2011) engages five dimensions of capacity, only the expertise and cultural dimensions of the framework exist within the individual domain. Resources existing at the individual level, contributing to the expertise dimension of capacity, include the knowledge and skills of teachers, administrators, and students making up the school. These resources overlap in nature with those present in human capital (Becker, 1993). An individual's knowledge and skill can be measured by experience and self-reported practices (O'Day et al., 1995). This study will include teachers' knowledge and skills specific to the classroom (e.g., pedagogical content knowledge) (Cohen & Ball, 1999). The cultural dimension of capacity, also proposed to exist at the individual level, consists of the dispositions, beliefs, and values of teachers and administrators (Spillane et al., 2003). Research indicates teacher's dispositions, beliefs, and values influence their instructional practices (Cross, 2009; Spillane et al., 2018; Yurekli et al., 2020). While not the focus of this study, characteristics from the individual domain influence how and what teachers learn from the opportunities they experience and can be used in aggregate form to better understand these characteristics at the organizational level.

Organizational Level

While individual characteristics have been shown to moderate and influence the implementation of reform-oriented teaching practices aligned with current content standards (Honig, 2006; Odden, 1991; Werts & Brewer, 2015; Young & Lewis, 2015), decisions made at the school or LEA can influence overall reform for the organization. The organizational level is representative of the collective of individuals making up a school including but not limited to teachers, administrators, staff, counselors, and students. The implementation of reform-oriented teaching practices involves collective interaction of the knowledge and interpretations of individuals and groups. The focus of this study is on the teachers as a learning community within the organization. As such, the following sections describe the dimensions of instructional reform capacity more specifically.

Expertise Dimension

Expertise is prevalent in the capacity of an organization to undergo instructional reform through the collective knowledge and skills across the individuals making up a collective group, in this case a school. By looking at expertise at the organizational level, the processes taking place between individuals to share expertise becomes a mechanism by which expertise can be shared and professional learning can take place. Teacher learning through professional learning communities (PLC) and collaborative working groups can contribute to the overall collective knowledge and skills contributing to organizational capacity (Stoll, 2009).

Cultural Dimension

The cultural dimension consists of the norms, climate, and characteristics present within a school influencing instructional reform. According to Malen (2006) norms are considered to be the "collective beliefs, values, and attitudes that have a measurable effect beyond that of the individual" (Hayes & Bae, 2016, p. 10). These norms are apparent in the rules, sociocultural values, and organizational structures or routines (Bryk et al., 2010; Malen, 2006; Scott, 2014). Climate is a key element of capacity and engages trust and collaborative culture (Bryk et al., 2010; Gamoran et al., 2003; Mitchell & Sackney, 2011; Seashore Louis & Lee, 2016; Spillane & Thompson, 1997). Characteristics of the cultural dimension include struggle between stability and change including the alignment or coherence between resources and instructional change initiatives (Datnow, 2005; Honig & Hatch, 2004). It also includes the struggle between distributed leadership and centralization of instructional reform (Mitchell & Sackney, 2011; Wieczorek & Lear, 2018).

Social Dimension

The social dimension of instructional capacity at the organizational level consists of the relationships and connections among people within and outside an organization. This dimension engages both social capital as well as political capital. This social network can support or constrain teaching, learning, and instructional reform implementation. Social relationships among teachers may significantly enhance teacher collaboration and can potentially contribute to instructional practices enacted by teachers as well as student learning (Moolenaar, 2012). Cosner (2009) found strong relationships between teachers can help to form the trust necessary for collective action. Within the social dimension, political capital references the ways in which social connections, positions, and reputation can be used to leverage action (Malen, 2006).

Structural Dimension

The organizational level of the structural dimension engages both technical capital and organizational structures. Technical capital is considered anything relating to money, physical materials, and resources. These include both academic and social supports for learning. Organizational structures "afford teachers a set of tools to advance student learning" (Bryk et al., 2010, loc. 620 of 3684) and can include curricular scope and sequence maps, instructional materials, and assessments methods. The coherence of organizational structures is important to their impact on instructional reform (Bryk et al., 2010).

Policy Dimension

The policy dimension at the organizational level consists of district policies and initiatives put in place that specifically target instructional reform. In some cases, district policies and initiatives can be translations of state and national policies put in place by school or district level leaders. Like other educational policies, these district policies can have designs, instruments, and documents (Honig, 2006).

External Level

Within the instructional reform capacity framework, the external level consists of both the community (e.g., parents, community organizations) as well as other educational stakeholders (e.g., businesses, government, state educational agency) outside of the immediate community who influence the resources present and processes utilizing those resources within schools. In this level, the expertise dimension consists of sources of expertise external to the organization. The cultural dimension consists of the social and political trends taking place that can influence the organization. The social dimension consists of civic capacity and community partnerships (Bryk et al., 2010; Honig, 2006). External sources of technical capital make up the structural dimension. Finally, the policy dimension consists of state and national policies (e.g., ESSA, science standards, CCSS). While this level of the framework is not directly examined in this study, these external conditions can influence the organization and may be present in the dimensions of instructional capacity reform at the individual and organizational level.

Alternative Frameworks to Instructional Reform Capacity

In order to attend to the complexity of the educational organization itself, several conceptual frameworks were considered. Some of the frameworks were proposed from a compilation of research findings. First, the NRC (2002) compiled initial research findings from the implementation of standards-based reform and identified channels of influence (e.g., curriculum, teacher development, assessment and accountability) on the implementation of these reforms. Additionally, Honig (2006) utilized a framework grounded in theory identifying the intersection of the spheres of policy, place, and people as influencing the implementation of educational reforms. While these frameworks provide insight and perspective, they were created to better understand a compilation of research findings at the time and were not used as a theoretically grounded framework for this study.

Other alternative frameworks that can be used to understand characteristics influencing elementary teachers' engagement with reform-oriented teaching practices include instructional guidance infrastructure (IGI) and social network. In the case of IGI, infrastructure is defined as structures and resources that are mobilized by local school systems to enable efforts to provide, maintain, and improve instruction (Hopkins & Spillane, 2015). While this framework provides insight into many of the avenues that enable instructional reforms, it neglects the sociocultural role at both the individual and interpersonal level in instructional change. In addition to the structure/infrastructure perspective, social networks can provide insight into the dynamics that impact instructional reforms. However, there is debate over whether social network is more of a research tool rather than a theoretically grounded framework (Moolenaar, 2012). Additionally, by only looking at the social interactions without the rest of the context, there are many gaps in the knowledge one can obtain from using a social network framework (Moolenaar, 2012)

Summary

The conceptual framework being utilized for this study for understanding the organizational context in which instructional practices are implemented by elementary science and mathematics teachers (Figure 3) has several benefits. First, it attempts to name and encapsulate the different elements of capacity, as noted in the literature, as well as conceptualizes their interaction with regards to instructional reform. It also allows for the school and LEA to be conceptualized as having the characteristics of an ecological organization. This recognizes the components of capacity as being interacting dynamically across dimensions (i.e.., expertise, cultural, social, structural, and policy) and levels (i.e., individual, organization, external). Lastly, this framework helps to understand or see where the connections and constraints exist between meaning and response with regards to implementation of instructional reforms. Utilizing this conceptual framework grounded in theoretical integration of both organizations and capitals can provide a better understanding as to the effects of the dimensions of an organization on the reform-oriented instructional practices promoted by science and mathematics content standards.

CHAPTER 3

METHODS

This chapter provides a description of the methods used to collect and analyze data for this study. Specifically, this study consists of two primary components including (1) the development and validation of a survey instrument to measure elementary teachers' teaching and learning experiences pertaining to science and mathematics instruction within the context of their school and (2) the analysis of data from the survey instrument to address the research questions.

Study Design

The purpose of this study was to measure elementary teachers' instructional practice use in science and mathematics lessons and to understand the relationship, if any, between their perceptions of the instructional reform capacity present in their work environment (i.e., their school) and their instructional practice use. The proposed framework of instructional reform capacity (see Figure 3, Chapter 2), utilized an ecological and constructivist understanding of instructional reform capacity (Hayes & Bae, 2016) consisting of five dimensions including expertise, cultural, social, structural, and policy. With this purpose in mind, this study addressed the following research questions:

1. What instructional practices do elementary teachers engage most frequently and to what degree do these practices align with reform-oriented instructional practices promoted by national teacher organizations?
    a. In science instruction?
    b. In mathematics instruction?

c. In science as compared to mathematics?

2. To what degree are the five dimensions of instructional reform capacity (*expertise*, *cultural*, *social*, *structural*, and *policy*) present at the organizational level associated with elementary teachers' use of reform-oriented instructional practices?

    a. In science instruction?

    b. In mathematics instruction?

    c. In science as compared to mathematics?

An online survey methodology drawing from previous research (Banilower et al., 2018; Blank et al., 2001; Buzick et al., 2019; Hayes et al., 2016; Hopkins & Spillane, 2015; Ross et al., 2003; Settlage et al., 2015; Yalçın & Ereş, 2018) in alignment with the conceptual framework described in the literature review was used for this study. The online format was chosen because it would be accessible for the population of focus (i.e., elementary teachers in a large suburban school district) and it would be more convenient for principals of schools to disseminate to the population of interest. A survey methodology was selected because schools and districts do not have the time or resources to investigate or examine the present state of capacity for instructional reform existing among their teachers. The reliance on big data to make decisions for local contexts inherently devalues the uniqueness of the individuals engaging within the context including their experiences, culture, and social interactions. Therefore, the development and validation of a survey instrument measuring instructional reform capacity and instructional practice use (1) provides a comprehensive research tool that did not exist before and (2) can assist schools and districts in making more informed decisions supporting instructional reform and professional development for teachers.

The first component of this study included the development and validation of a survey instrument because there are no preexisting surveys measuring elementary teachers' perceptions of their instructional practice use for science and mathematics as well as their perceptions of capacity for instructional reform present at the organizational level (i.e., within the school in which they worked). The survey was developed as part of a multi-step process including a literature review, two expert panel reviews, and a round of cognitive interviews. An inclusive literature review of both qualitative and quantitative research was necessary for survey development because much of the research related to the components of the conceptual framework and instructional practice use is qualitative in nature. To ensure validity, I put the survey through a three-step validation process prior to its administration. Two expert panels, one containing experts in the conceptual framework and one containing experts in the content areas of elementary science and mathematics helped reduce the number of items, improve alignment with the conceptual framework and research questions, and improve wording for understanding. After modifications to the survey, cognitive interviews with three elementary teachers helped modify wording of the items and provide relevant examples to ensure consistent meaning for all respondents. The goal of this development and validation process was to create a survey aligned to the research questions and respectful of the context of elementary teachers included in this study.

The second component of this study included administration and analysis of the survey. The survey was administered to elementary teachers responsible for teaching science and/or mathematics in a single district in a southwestern state within the United States. In order to obtain a large enough sample size to analyze the behavior of the items, an entire district was sampled. Because instructional reform capacity can be present at different levels (i.e., individual, interpersonal, organizational, external) it was essential to limit the participants to a single school district. In this study, the external level acted as a control (Hayes & Trexler, 2016). Analysis of the data started with reliability and behavior of the survey items within the instructional reform capacity and instructional practice sections of the survey. Reliability measurements as well as factor analyses enabled me to determine which items could be used to answer the research questions and the underlying factor structure representing the dimensions of instructional reform capacity. Evaluation of descriptive and inferential statistics, including t-tests and correlations addressed the research questions of this study.

Survey Development

This study required the development of a survey since my review of the literature found no preexisting survey instruments aligned with both teachers' instructional practices and the conceptual framework (see Figure 3, Chapter 2) used in this study. Additionally, data compiled from large data sets did not have enough questions to address the research questions for this study. The Elementary Science and Mathematics Instructional Reform Capacity (ESMIRC) survey was designed to measure elementary teachers' perceptions of their science and mathematics instructional practice use and examine the relationship between their instructional practice use and their perceptions of instructional reform capacity (e.g., *expertise, cultural*, *social*, *structural,* and *policy*) present in their organization. In this study, the organizational level was considered to be the school in which the teacher worked at the time of the study. Survey development included multi-step process to ensure validity and reliability prior to administration. This section provides a description of the survey development process including a review of the literature, two expert panel reviews, and a round of cognitive interviews.

Review of the Literature

Development of the ESMIRC survey instrument started with a review of the literature to compile a database of studies and surveys (Nardi, 2018). The review of the literature was focused on the two major sections of the survey including instructional reform capacity aligned with the conceptual framework of this study and instructional practices used in elementary science and mathematics. Various keyword searches were performed in multiple databases (e.g., ERIC ProQuest, Google Scholar) to identify literature aligned with instructional practices and the conceptual framework. The literature review was not limited to quantitative or survey methodology research because of the extensive qualitative research examining the impact of instructional practice reforms completed since the inception of standards-based reform. Additional methodologies and qualitative research provided insight into salient characteristics of schools effective in shifting teachers' instructional practices and therefore had to be included to inform development of the survey. The compiled literature used to create an initial set of survey items consisted of qualitative, quantitative, and mixed methods studies. Due to the intersection of instructional reform capacity and instructional practice use, studies referenced during survey development are presented by topic with which they align (i.e., instructional reform capacity and instructional practice use).

Instructional Reform Capacity

In alignment with the research questions, instructional reform capacity survey items targeted the organizational level (i.e., the school) and aligned with the conceptual framework dimensions (e.g., *expertise*, *cultural*, *social*, *structural*, and *policy*) for this study (see Figure 3, Chapter 2). The five dimensions (e.g., *expertise*, *cultural*, *social*, *structural*, and *policy*) of the instructional reform capacity framework merged the constructivist and ecological perspectives of collective learning existing within organizations. The initial set of 97 survey items was informed by preexisting survey items as well as salient findings from literature aligned with the conceptual framework.

Preexisting surveys items aligned with the dimensions (e.g., *expertise*, *cultural*, *social*, *structural*, and *policy*) of instructional reform capacity (Banilower et al., 2018; Hayes et al., 2016; Hopkins & Spillane, 2015; Settlage et al., 2015; Spillane et al., 2003; Yalçın & Ereş, 2018) were used to inform the initial set of survey items. For example, items from the National Survey of Science and Mathematics Education (NSSME) were used to inform ESMIRC items because of their alignment with the conceptual framework and their evaluation for reliability (Banilower et al., 2013, 2018). These Likert-scale items are sampled nationally in grades K-12 across the 50 states and the District of Columbia. Their coefficient alpha measurements were calculated for the constructs related to mathematics and science education and ranged between 0.6 and 0.9. An alpha of 0.6 to 0.8 indicates a moderate reliability while a value over 0.8 is considered evidence of a strong reliability (Cronbach, 1951). In addition to the NSSME, Likert-scale items from a survey examining aspects of the school organization that provide, maintain, or shift instruction as part of a longitudinal mixed methods study (Hopkins & Spillane,

2015) were used to inform items. Reliability of the survey items was determined based on a factor analysis of the dimensions (e.g., regulative, normative, or cultural-cognitive) with Cronbach's alpha measurements ranging from 0.82 to 0.92 on average for multiple years of data. The alignment of survey items from these two surveys with the conceptual framework used in this study along with the reliability measurements of the items reinforced their use of informing item development for the ESMIRC survey.

Additionally, items from surveys having frameworks based on capitals were used, with permission, in the ESMIRC survey. First, survey items from the School Science Infrastructure (SSI) survey, grounded in social capital theory (Coleman, 1988), were used in the initial item pool. These items focused on three interrelated features of social capital including social norms, information channels, and reciprocating relationships (Settlage et al., 2015). This 64-item survey, developed by a research team, measured teacher perceptions about their schools' organizational structures and leadership practices and underwent multiple validations and three pilot tests. Items with a 5-point Likert scale for agreement ranging from *strongly disagree* to *strongly agree* were used, with permission, on the ESMIRC survey. Furthermore, the Science Instructional Practices survey (SIPS), developed as part of a professional development program for science teachers, having survey items focused on organizational characteristics associated with teachers' instructional beliefs or practices (Hayes et al., 2019) were included in the ESMIRC survey. Multiple items having various 5-point Likert response scales (e.g., frequency of use, agreement, level of truth, level of input), from SIPS were modified to be statements that could be answered with an agreement response scale. All scales ranged from negative to positive or low to high (e.g., *no input* to *high input*). While survey items were used with permission, some were modified during the course of the ESMIRC development process.

Furthermore, items were developed from findings using alternative methodologies to survey research (Berends, 2004; Bryk et al., 2010; Coburn, 2003; Daly, 2009; Ertmer, 1999; Honig, 2003; Leithwood & Mascall, 2008; Mitchell & Sackney, 2011; Smylie & Evans, 2006). Items were created from findings aligned with the five dimensions of instructional reform capacity and were written for the perspective of the organization (i.e., the school). Bryk et al. (2010) examined the role of social relationships in schools and their impact on student achievement. Their findings focused on the role of relational trust in schools trying to improve concluding that while trust will not improve schools, it must be present in order for schools to improve. Ertmer (1999) looked at barriers to implementation of technology by teachers finding that while some teachers are limited by first-order barriers (e.g., training, support, materials) others are limited by second-order barriers (e.g., deeply held beliefs about teacher-student roles). While technology is not the focus of this study, technology implementation and implementation, in general, is an essential component of the teaching environment. Research from Mitchell and Sackney (2011) focused on the role of professional learning on capacity building in schools and provided characteristics informing some ESMIRC survey items. While findings from qualitative and mixed-methods research can be limited in its generalizability, its inclusion was essential to ensure the ESMIRC survey items were more holistic and inclusive in their representation of the school environment in which teachers teach.

Instructional Practice Use

Instructional practices present in the survey aligned with both reform-oriented practices promoted by nationally recognized organizations (e.g., NCTM, NRC, and NSTA) as well as non-reform-oriented practices (NCTM, 2014; National Research Council, 2012). This range of items recognizes teachers' practices as being on a spectrum ranging from less reform-oriented to more reform-oriented as well as teachers' choice of instructional practice use based on the needs of students they teach. The initial set of survey items were informed by preexisting survey items as well as findings from literature aligned with instructional practice use for elementary science and mathematics.

Survey items from prior research aimed at measuring teachers instructional practice use (Banilower et al., 2018; Blank et al., 2001; Hayes et al., 2016; Ross et al., 2003) were used to inform survey items contained within the ESMIRC survey. First, items from the National Survey of Science and Mathematics Education (NSSME), targeting the implementation of science and mathematics instruction within the K-12 educational setting, were used to inform items on the ESMIRC (Banilower et al., 2018). Selected items from the NSSME used a 5-point Likert scale for frequency of use from *never* to *all or almost all lessons*. In addition to the NSSME, items from the Surveys of Enacted Curriculum in Mathematics and Science, created to evaluate the effects of standards-based reforms on instruction, were used to inform ESMIRC items (Blank et al., 2001). The original response scale of these items was a 4-point Likert for the amount of instructional time spent on each practice ranging from *none* to *more than 33%*. Reliability coefficients for the science and mathematics scales within the survey ranged from 0.60 to 0.92 meeting the recommended minimum for reliability (Cronbach, 1951). Furthermore, items from the Science instructional practices survey (SIPS), specifically targeting science instructional practices appropriate for NGSS and other related science standards, were used with permission. These items had a 5-point Likert scale for the frequency of use ranging from *never* to *daily or almost daily*. Taken together, items on the ESMIRC survey targeting instructional practices of teachers' science and mathematics are informed by or are used, with permission, from prior studies and validated surveys.

Survey Validation

The initial version of the survey compiled from the literature review was checked for content validity through the use of expert panel reviews (Nardi, 2018). The first expert panel review included experts with experience in survey construction and administration and content knowledge in organizational capacity and instructional practices. The second expert panel consisted of practitioners with extensive experience in K-12 science and mathematics instruction and familiarity with the context of teachers within the target population. Revisions to the survey were made based on feedback following each expert panel iteration. For example, the item "I work with colleagues at my school to develop shared meanings of __________ teaching and student learning" was modified from the original item "I compare new teaching pedagogies to my prior knowledge" to improve clarity and interpretation.

The ESMIRC survey was piloted using cognitive interviews of a convenience sample of three elementary school (K-6) science and/or mathematics teachers in Arizona. The objective of the pilot was to determine face validity of the survey items and make any modifications prior to the survey's administration to the target population. Cognitive interviews use verbal probing techniques to not apparent problems related to question wording, ordering, or format and collect suggestions for how to fix the problems from individuals similar to the intended population (Willis, 2004). Potential participants were recruited based on their professional relationships with myself or individuals involved in science and mathematics education at the state or university level. Selected participants taught science and/or mathematics at the primary level but were not part of the intended population for survey administration. In compliance with the IRB, the email solicitations for the cognitive interview contained detailed information about the purpose of the study as well as the contact information for the supervising faculty and IRB at ASU. Individual respondents consented to participating in the interview through the first question on the survey. A $30 Amazon gift card was given to all teachers participating in the cognitive interviews.

The cognitive interview protocol combined methods of prompting questions and think-aloud (Blair et al., 2014). The cognitive interview protocol can be found in Appendix A. Participants were asked to think-aloud as they participated in the survey through Qualtrics. The purpose of the think-aloud was to get a better understanding of what the participant was thinking while answering the survey item (Blair et al., 2014). Additionally, participants were prompted at regular intervals (i.e., every five survey items) during the interview for feedback on the wording, organization, and flow of the items. Data was collected during the cognitive interviews in the form of notes, a recording, and memos following the interview. Qualitative data from the cognitive interviews was analyzed to inform survey modifications. Repetition, similarities and differences, word frequency, and linguistic connectors were used to identify patterns and themes for potential survey modifications (Bernard et al., 2017). Within the cognitive interviews, a common theme was confusion on the “who” referenced in the survey items so several items were modified to specify “at my school.” In addition, the cognitive interviews provided feedback for examples to be provided in the item. For example, the item “I regularly plan lessons, activities, and tests with my teacher colleagues” was modified to “I regularly work with other teachers at my school to develop or plan __________ instruction (for example: goals, objectives, lessons, activities, labs)”. The findings were used to inform modifications to the ESMIRC survey including item wording, structure, and flow before its broader administration.

ESMIRC Survey Instrument

The ESMIRC survey serves three main goals: (1) to measure elementary teachers’ self-reported instructional practice use during science and mathematics lessons, (2) to assess elementary teachers’ perceptions of instructional reform capacity present at their school, and (3) to measure the level of association between self-reported instructional practice use and perceived instructional reform capacity at the organizational level in which teachers teach. In this section I provide the taxonomy of the final survey and then discuss the items present within the different sections of the survey. The complete survey consisting of 91 items can be found in Appendix B.

Survey Taxonomy

The taxonomy of the survey includes questions to capture characteristics of the teacher, their background and demographics, instructional reform capacity, and instructional practice use. The items for instructional reform capacity align with the conceptual framework used in this study consisting of five dimensions including *expertise*, *cultural*, *social*, *structural*, and *policy* (refer to Figure 3, Chapter 2). The instructional practice items are aligned with teacher-centered, lecture-based and student-centered, activity- or inquiry-based instructional practices. Student-centered, lab- or activity-based instructional practices (i.e., reform-oriented instructional practices) are those espoused by national organizations. The survey has four sections in its taxonomy including (1) teacher role, (2) instructional reform capacity, (3) instructional practices, and (4) teacher background and demographics (Table 1).

Table 1

ESMIRC Survey Taxonomy

1.0 Teacher Role
- 1.1 Subject area
- 1.2 Grade level(s)
- 1.3 Teaching format
- 1.4 Teaching role
- 1.5 Structure of instruction
- 1.6 District
- 1.7 School

2.0 Instructional Reform Capacity
- 2.1 Expertise
- 2.2 Cultural
- 2.3 Social
- 2.4 Structural
- 2.5 Policy

3.0 Instructional Practices
- 3.1 Quantity of lessons
- 3.2 Instructional practices

4.0 Teacher Background and Demographics
- 4.1 Professional Development experiences
- 4.2 Years of teaching experience
- 4.3 Education background
- 4.4 Sex
- 4.5 Race

Teacher Role

The teacher role section of the survey contained seven items that gathered descriptive information about the teacher's role in science and/or mathematics instruction over the last month (four weeks). The questions targeted information about the subject and grade level taught, format of instruction (e.g., in-person, virtual, or combination), teaching role (e.g., self-contained, specialized, or pull-out), the structure of instruction students received (e.g., discipline-specific or interdisciplinary and who provides it), and the school in which they taught. Multiple response options were presented for each question allowing for a diversity of instructional scenarios.

Some of these initial items provided the basis for filtering during survey participation or grouping of data for analysis. The survey item asking teachers about the subject they taught was used to filter respondents to alternative presentations of survey items that came later in the survey. For example, if a teacher only taught science, the survey items for instructional reform capacity and instructional practices would only have the Likert options for science instruction. In addition, many of the items in this section allowed for grouping of responses for analysis including subject taught and instructional format.

Instructional Reform Capacity at the Organizational Level

The next section of survey items assessed teachers' perceptions of the five dimensions (i.e., *expertise*, *cultural*, *social*, *structural*, and *policy*) of instructional reform capacity at their place of work (Table 2). The survey items within this section were organized into subsections aligned with the proposed dimensions of the conceptual framework presented in the literature review (refer to Figure 3, Chapter 2). Survey items had a fill-in the blank structure allowing teachers to respond uniquely for science and mathematics instruction depending upon their described teacher role from prior survey items. An example survey item is "Materials for __________ instructional activities are accessible (for example: books, supplies)". For teachers of both science and mathematics, the items were matrixed side by side allowing survey participants to respond uniquely for science and mathematics instruction. The survey participant would respond to the survey item on two separate Likert scales, one being for science and one being for mathematics. All items in these sections ask respondents to indicate their level of agreement using a 6-point Likert scale ranging from *strongly disagree* to *strongly agree*.

Table 2

Instructional Reform Capacity Dimensions in the ESMIRC Survey

Dimension	Description	# Items	Example Item
Expertise	collective use of knowledge and skills within an educational system (Newmann et al. 2000; Stoll, 2009)	10	I plan __________ instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity.
Cultural	collective" expressive and affective dimensions" and system of shared meanings, ideology and values within the organization (Allaire & Firsirotu, 1984, p. 213)	13	I am free to participate in professional communities or learning communities focused on __________ teaching and learning as I see fit.
Social	relationships and connections among people (Newmann et al., 2000)	9	I regularly work with other teachers at my school to develop or plan __________ instruction (for example: goals, objectives, lessons, activities, labs).
Structural	codified and tangible elements of capacity (Hayes & Bae, 2016)	10	There is sufficient technology to provide students with opportunities for __________ learning (for example: computers, Wi-Fi, Google Classroom, SeeSaw).
Policy	policies, priorities, and initiatives that can carry resources (Newmann et al., 2000; Malen, 2006)	9	Curriculum maps/Pacing guides facilitate instructional practices that promote student learning in __________.

Note. Underscored segments of items indicate where teachers were to fill in science or mathematics.

Expertise

Statements contained within the expertise subconstruct specifically addressed the skills, knowledge, dispositions, and identity of elementary teachers (Newmann et al., 2000; Stoll, 2009). Some items contained within this section were modeled after survey items used in prior research that aligned with the expertise dimension as described by the conceptual framework (see Figure 3, Chapter 2; Banilower et al., 2018; Settlage et al., 2015; Yalçın & Ereş, 2018). This section contained ten statements including "I am committed to learning new knowledge and skills for __________ teaching and learning" and "I work with colleagues at my school to develop shared meanings of __________ teaching and student learning" where the fill-in blank was considered science or mathematics.

Cultural

The cultural dimension section specifically addressed the norms, climate, and characteristics of the organizational context in which elementary teachers teach (Allaire & Firsirotu, 1984). Some items were modeled after other surveys targeting a better understanding of teachers' cultural context (Hayes et al., 2016; Hopkins & Spillane, 2015; Settlage et al., 2015; Yalçın & Ereş, 2018). Additional items were created based on research findings focused on instructional reform (Bryk et al., 2010). There are 13 statements including "I have a voice in what happens in my classroom for __________ teaching and learning (for example: curriculum and instruction)". Within the statements, four items focused on the relationship between leadership and culture. An example item is "My administrators clearly communicate the importance of __________ instruction." The fill-in blanks present in the items allowed independent responses for science and mathematics.

Social

Survey items representing this dimension of instructional reform capacity targeted social and political capital, including relationships and connections among people within the professional community (Newmann et al., 2000). Items within this section were modeled after other surveys aiming to better understand the role of social interactions within the teacher community at a school (Hayes et al., 2016; Settlage et al., 2015). Additional items were developed based on instructional reform literature (Bryk et al., 2010). This section consists of ten statements. An example of an item aligned with this dimension is “I regularly work with other teachers at my school to develop or plan __________ instruction.” Survey participants replaced the fill-in blank with science or mathematics depending upon the subjects they taught.

Structural

Items within this dimension section addressed the codified and tangible elements of capacity including technical capital, organizational structures, and instructional guidance structures present within an organization which was specified as the school for this research (Hayes & Bae, 2016). This section consisted of ten survey items, most of which were created based off of research findings focused on instructional reform (Bryk et al., 2010; Ertmer, 1999; Mitchell & Sackney, 2011). An example of a general item in this section is “Instructional materials used at this school are cohesive.” A subject specific item example is “There is sufficient time for __________ instruction and learning in this school.” The fill-in blank was replaced by either science or mathematics depending upon the subject(s) the teachers taught.

Policy

The policy dimension section of the survey targeted the presence of policies and initiatives at the organizational level (i.e., school-level) that can carry resources (Malen, 2006; Newmann et al., 2000). This section includes nine items, most of which were modeled after or used directly, with permission, from survey items used in research to understand the impact of policies on instructional reforms (Hayes et al., 2016; Hopkins & Spillane, 2015; Settlage et al., 2015). Some items were created based on research aimed at understanding the role of policies in instructional reform (Bryk et al., 2010; Mitchell & Sackney, 2011). An example of an item from this section was “School directives and initiatives are aligned with current state __________ standards.” The fill-in blank was replaced by either science or mathematics based on the subject area(s) the responding teacher taught.

Science and Mathematics Instructional Practice Use

The next section of the survey examined science and mathematics instructional practice use and contained two subsections (Table 3) targeting the characteristics of instruction as well as the teachers’ perceived use of specific instructional practices during instructional time. The first subsection assessed the frequency of science and mathematics instruction which asked respondents how many lessons were provided in the last month. For the purposes of this survey, lessons were specified as being 45 minutes to one hour in length. Lessons could be divided up over the course of multiple days or integrated with other subject areas. The instructional practices subsection was divided into two chunks including ten items each intended to better understand the science and mathematics instruction taking place in the classroom. The survey items covered the spectrum of instructional practices from reform-oriented (i.e., student-centered and activity- or inquiry-based) to more teacher-centered, lecture-based. Due to the overlapping nature of these survey items, a fill-in blank structure was used which enabled teachers to respond uniquely for science and mathematics instruction. The structure of the survey directed respondents to the questions appropriate to their teaching role depending upon whether they taught math and/or science.

Table 3

Instructional Practices Subsections in the ESMIRC Survey

Subsection	Description	# Items	Example Item(s)
Instructional characteristics	Frequency of the science and mathematics instruction taking place	2	In the last month (four weeks), how many lessons (45 min-1 hour) of science and mathematics instruction were provided to your students (including lessons integrating science with other subjects)?
Instructional practices	Characteristics of classroom instruction and learning present	20	*How often did the following take place during your science and/or mathematics lessons in the last month (four weeks)?* Direct instruction to explain or reinforce ___________ concepts to the whole class A conceptual model was developed based on data or observations (model is not provided by textbook or teacher) (for example: graphs and data displays)

Note. Underscored segments of items indicate where teachers were to fill in science or mathematics.

Teacher Background & Demographics

The teacher background and demographics section contained items pertaining to the background and demographics of the teacher including their professional development experiences, years of experience, level of education, sex, and race. Teachers are asked to provide information regarding the duration and alignment of their professional development related to science or mathematics for the past two years. The time was set for two years because of the potential impact of the coronavirus pandemic on a teacher’s ability to access, afford, or participate in professional development during the pandemic. The questions for sex and race provide preset choices for respondents in alignment with the U.S. Census Bureau questions. The race question allows selection of multiple races for respondents. These survey items provided data that can be controlled for in the analysis.

Participants and Sampling Procedures

Prior to administering the survey, I obtained approval from both the Institutional Review Board (IRB) at Arizona State University (ASU) as well as the participating district’s Research Committee (Appendix C). In compliance with the IRB, the email solicitation for the survey contained detailed information about the purpose of the study, the contact information for the supervising faculty and IRB at ASU, and a link to the survey (Appendix D). Consent was acknowledged by the participant clicking “Yes” in response to the first question on the survey. Incentives, a $15 Amazon gift card, were provided to the first 200 teachers who participated in the survey. Gift card distribution was determined by the information provided on a separate survey linked to the end of the ESMIRC survey.

School information was compiled from school websites and publicly available data sets (e.g., Elementary/Secondary Information System (ElSi) and Arizona Department of Education). The targeted group for this study was in-service elementary (K-6) teachers providing science and/or mathematics instruction to their students. Although upper elementary grades are more likely to be departmentalized, most elementary schools within the sampled district did not departmentalize their upper grade levels. Therefore, I did not exclude 5th and 6th Grade teachers from the sample but instead incorporated questions into the ESMIRC survey to identify them and present the survey items in a manner more aligned with their departmentalized teaching experiences (i.e., they only responded to items for a single subject, either science or mathematics, and not both).

The final version of the survey was administered after elementary schools were in session for at least one month in the fall of 2021. The initial sample was determined by matching schools based on their characteristics (e.g., free-and-reduced lunch (FRL), Title I status, letter grade, enrollment, student to teacher ratio, and programs availability (e.g., AVID, STEM, PBIS, Montessori)) and then randomly selecting from the match in order to get a purposefully representative sample of the district programs and demographics. The initial sample had schools with an average of 22 K-6 teachers, 627 students, and free and reduced lunch percentage of 59.9%. The average school across the entire district had 22 K-6 teachers, 605 students, and a free and reduced lunch percentage of 59.6%.

In collaboration with the district, the online survey solicitation was emailed to elementary school leadership (e.g., principal and/or principal secretary) from a large suburban school district located in Arizona. The email contained a solicitation to be forwarded to their teachers regarding participation in a one-time survey (Appendix D). This approach, sampling from a purposefully selected sample, was taken in order to minimize disruption to the teachers in the district. Based on initial response rates from the sample, I decided to expand the sampling to the rest of the district schools in an attempt to obtain more responses. The research questions required a sufficient sample size to do a factor analysis. I then reached out to the school leadership of the remaining schools via email to distribute the solicitation.

The survey's four-week administration was hosted through Qualtrics and participation was supported using several approaches. During its administration, two reminder emails were sent to principals to improve the response rate among teachers. The first reminder was sent after one week of instruction had taken place after the initial notification. The final reminder was sent when there was approximately one instructional week remaining in the four-week administration period. The reminder emails can be found in Appendix D. In addition to emails, I called the schools to touch base with the principal or principal's secretary to discuss the survey and support its dissemination in any way I could. I was asked to visit one school to introduce and speak about the survey during its administration. Although two sample periods were administered, due to the two sample groups, both samples followed the same timeline of administration and reminders. In addition to reminders and phone calls, the first 200 teachers to participate in the survey received an incentive in the form of a $15 gift card.

Data Analysis

Data analysis included a multi-step process to ensure data quality and reliability to address the research questions. I evaluated the behavior of the data including missing data to determine the sample. Once a sample was determined, initial analyses of the survey data included coefficient alpha of the instructional reform and instructional practice items to determine reliability. Additionally, factor analyses were performed with data from the instructional reform capacity items to determine the constructs present and the extent to which they align with prior studies and the conceptual framework being utilized (Hayes & Bae, 2016; Settlage et al., 2015). The research questions were answered through the use of descriptive and inferential statistics.

Initial data behavior focused on missing data and outliers. Evaluation of missing data and outliers is important for survey research because non-response can indicate some level of difference between respondents and non-respondents which must be evaluated (Bryson et al., 2012). Responses were evaluated for inclusion in the sample based on percentage of valid responses within sections of the survey. A threshold amount of missing data was used as a cutoff for inclusion in the sample. Next, the data was examined for normality because a non-normal distribution is more likely with the Likert scale nature of the survey data and has implications for how it is analyzed (Jamieson, 2004; Sullivan & Artino, 2013). Data was assessed for normal distribution and adherence to other assumptions of the statistical tests being used to answer the research questions (Pett et al., 2011). If the data are found to be distributed normally or within the parameters of the assumptions of the statistical tests, parametric approaches will be taken to address the research questions. If a non-normal distribution is found, non-parametric approaches will be used to address the research questions.

Coefficient alpha calculations were performed to determine if survey items should be removed prior to factor analysis (Cronbach, 1951). Due to the multidimensional nature of the survey, coefficient alpha was calculated for specific sections within the survey (i.e., instructional reform capacity and instructional practices) rather than across the entire survey (Cortina, 1993). For the instructional reform capacity items, coefficient alphas were performed for individual dimensions as well as all of the items together. Any items significantly unreliable were removed prior to the factor analysis. Instructional practice use items were also analyzed using coefficient alpha to determine reliability and determine removal of any items prior to analysis.

The ESMIRC survey measured participant perceptions of instructional reform capacity and does not represent a standardized or objective measurement; therefore, factor analyses were performed using MPlus 8.7 to determine the underlying structure of the instructional reform capacity items (Muthén & Muthén, 2021). Survey items for science and mathematics were analyzed independently of one another in alignment with the research questions. First, the data was analyzed for factorability using polychoric correlations, Kaiser-Meyer-Olkin Test of Sampling Adequacy, and Bartlett's Test of Sphericity (Beavers et al., 2013). Once factorability was supported, factor validity was explored using both confirmatory and exploratory factor analyses using the conceptual framework for this study as a starting point (see Figure 3, Chapter 2). The analyses identified items to be considered for removal as well as identified which items should be included in calculating composite measures of the dimensions to address the research questions.

Composite measures were created for the dimensions underlying instructional reform capacity as well as teacher-centered and student-centered instructional practice use to address the research questions. The survey items included in the instructional reform capacity composites were determined from the factor analyses (DiStefano et al., 2009). It is important to note that the composite measures are not objective measures of the dimensions of instructional reform capacity but rather teacher's perceptions of instructional reform capacity found within the context in which they teach. In addition, composite scores were created for instructional practices (i.e., teacher-centered and student-centered) to address the research questions. These composites were created based on factor analyses performed on data from the SIPS survey (Hayes et al., 2016).

The research questions were addressed in a multi-step process. First, I performed descriptive statistical analyses in SPSS 26 to determine how frequently elementary teachers reported using instructional practice in their science and mathematics lessons. The 5-point Likert scale was condensed to three groups of use (e.g., less than half of lessons, about half of lessons, and more than half of lessons). Using this descriptive analysis, I assessed the level of integration of teaching practices for both science and mathematics. It is important to note that these findings are not based on observation of in class instructional use but are representative of teachers' self-reported perception of use. I employed descriptive statistics with the instructional practice composite measures to compare how frequently teachers use reform-based (i.e., student-centered and activity- or inquiry-based) instructional practices as opposed to teacher-centered, lecture-based practices. As part of the initial descriptive analyses, I was able to answer two of the subquestions of the first research question:

1. What instructional practices do elementary teachers engage most frequently and to what degree do these practices align with reform-oriented instructional practices promoted by national teacher organizations?
    a. In science instruction?
    b. In mathematics instruction?
    c. In science as compared to mathematics?

In order to compare instructional practice use between science and mathematics lessons, the third subquestion of the first research question, the difference between reported instructional practice use in science and mathematics was calculated. This difference was calculated on matching survey items across both science and mathematics was analyzed using paired samples t-tests. Additionally, composite measures of teacher-centered and reform-oriented instructional practices were analyzed between science and mathematics using paired samples t-tests.

To address the second research question examining the relationship between the teachers' perceptions of the dimensions of instructional reform capacity at the organizational level and elementary teachers' self-reported use of reform-oriented instructional practices, I analyzed the data using correlations. The composite measures of teacher-centered and reform-oriented instructional practices were correlated with the composite score of each dimension of instructional reform capacity. Items included in the composite measures of instructional reform capacity were based on the findings from the factor analyses done with the collected data. In doing this analysis, I was able to address the first two subquestions of the second research question:

2. To what degree are the five dimensions of instructional reform capacity (*expertise*, *cultural*, *social*, *structural*, and *policy*) present at the organizational level associated with elementary teachers' use of reform-oriented instructional practices?
    a. In science instruction?
    b. In mathematics instruction?
    c. In science instruction as compared to mathematics?

The third subquestion of the second research question was addressed through correlations comparing science and math instructional reform characteristics at the respondent level.

Summary

The methodological approach utilized for the development, administration, and data analysis of the ESMIRC survey has several benefits in promoting further understanding of the perceived presence of reform-oriented instructional practices as well as the role of the organization in influencing the implementation of these instructional practices. First, it allowed for the development of a survey compiled from current research of instructional reform capacity and the spectrum of instructional practices that was validated by experts and teachers. This survey recognized the components of capacity as interacting dynamically across dimensions. Furthermore, the survey and its analysis allowed local educational leaders access to theoretically grounded and research-based information specific to their context. This application and approach can bridge the connection between research and practitioners and provide educational leaders with the information, specific to their context, to make more informed decisions for their context.

CHAPTER 4

RESULTS

This chapter reports this study's research findings which aimed to understand the general elementary (i.e., K-6) education teachers' teaching and learning experiences related to science and mathematics instruction. Specifically, this study consisted of two primary components including (1) the development and validation of a survey instrument to measure elementary teachers' instructional reform capacity and instructional practice use pertaining to science and mathematics instruction within the context of their school and (2) the analysis of survey data to address the research questions. The research questions addressed in this study are as follows:

1. What instructional practices do elementary teachers engage most frequently and to what degree do these practices align with reform-oriented instructional practices promoted by national teacher organizations?
   a. In science instruction?
   b. In mathematics instruction?
   c. In science as compared to mathematics?
2. To what degree are the five dimensions of instructional reform capacity (*expertise*, *cultural*, *social*, *structural*, and *policy*) present at the organizational level associated with elementary teachers' use of reform-oriented instructional practices?
   a. In science instruction?
   b. In mathematics instruction?
   c. In science as compared to mathematics?

The results of this study are presented in alignment with the two component parts of this study. First, the final sample is described in terms of demographics and institutional characteristics. Second, the validation process of the ESMIRC's instructional reform capacity items using factor analysis is described and the results are presented. Next, descriptive statistics are presented to explore the nature of the data and to attend to the first research question regarding instructional practice use for science and mathematics lessons. Finally, to address the second research question, correlations are presented to examine the relationship between teachers' reported instructional reform capacity and their instructional practice use for science and mathematics instruction.

Sample Description

A total of 338 elementary teachers participated in the ESMIRC survey. A total of 164 elementary teachers met the inclusion criteria used to determine the sample to address the research questions for this study. Participation was considered to be consenting to the survey, teaching one or both subjects (i.e., science and/or mathematics) in grades K-6, and completing the teacher role section of the survey. The initial sample ($n = 247$) included teachers who taught both science and mathematics to elementary (K-6) students in-person and considered themselves to be self-contained teachers. Responses excluded from this sample included those who taught only science or mathematics, did not consider themselves a self-contained teacher (e.g., subject specialist, pull-out instructor, etc.), and taught virtually. Additionally, survey responses were excluded if they had more than 20% missing data ($n = 83$). A majority (69%) of the responses removed in this final step completed less than one-third of the survey responses necessary to address the research questions ($n = 57$). Additionally, most of the incomplete items were instructional practice items which were necessary for analysis to answer the research questions. The final sample (*n* = 164) consisted of elementary (K-6) teachers providing in-person instruction for both science and mathematics who completed 80% of the items necessary to address the research questions.

The final sample consisted of 164 individuals who taught in-person elementary science and mathematics in a self-contained setting and completed at least 80% of the ESMIRC survey. Table 4 provides a breakdown of characteristics of these teachers including demographics and educational background. Of the 164 teachers, most were female (*n* = 154, 93.9%). When reporting their ethnicity, most participants (*n* = 136, 83.9%) were White while others classified themselves as either Hispanic (*n* = 15, 9.2%), Multiracial (2 or more races) (*n* = 11, 6.7%), or American Indian/Alaskan Native (*n* = 1, 0.6%). Additionally, a majority of teachers (*n* = 158, 96.3%) reported having earned a Bachelors or graduate degree in education. Of these degrees, almost 90% (*n* = 145) were in elementary education. In addition to higher education degrees in elementary education, teachers reported having degrees in early childhood (*n* = 9), special education (*n* = 4), and English as a Second Language (ESL) (*n* = 3). Non-education degrees included business (*n* = 4), counseling (*n* = 3), and psychology (*n* = 3). Overall, the elementary teachers involved in this study reported being predominantly White females who have earned a Bachelor's or graduate degree in elementary education.

Table 4

Elementary Teachers' Demographics and Educational Background (n =164)

Characteristic	*n*	%
Gender		
Female	154	93.90
Male	7	4.27
Prefer not to say	3	1.83
Race[a]		
American Indian	1	0.61
Hispanic	15	9.15
White	136	82.93
Multiracial	11	6.71
Missing	1	0.61
Earned Bachelor's or Graduate Degree[b]		
Education	158	96.34
Mathematics	1	0.61
Natural Science	6	3.66
Other	35	21.34
Multiple Degrees	33	20.12
Education Degrees Earned		
Elementary	145	88.41
Secondary	4	2.44
Mathematics	1	0.61
Science	2	1.22
Other	41	25.00
Multiple Education Degrees	34	20.73

[a] Asian, Black, and Hawaiian/Pacific Islander had 0 respondents. [b] Computer Science and Engineering had 0 respondents.

The data collected representing teachers' professional characteristics included the grade(s) they taught and their years of teaching experience (Table 5). Of the respondents, at least 30 teachers taught each grade from Kindergarten through 3rd Grade. A majority of survey respondents (*n* = 90; 52.6%) indicated teaching in the early elementary grades (i.e., K-2). Sixth and fourth grade had the least representation within the sample (*n* = 13, 7.9% and *n* = 19, 11.6%, respectively). A majority of teachers taught a single grade level (*n* = 150, 91.5%). In contrast, 14 survey participants taught multiple grade levels (see Table 2). Of those who taught multiple grade levels, seven taught two grade levels in the middle elementary grades (i.e., 3rd and 4th Grade) (*n* = 7/14, 50%). Teachers had an average of 14.2 years of teaching experience with a majority of teachers (*n* = 125, 75.8%) having 20 years or less of teaching experience. Teachers with over 20 years of experience made up less than one-quarter of the sample (*n* = 40, 24.2%). Overall, teachers largely taught single grades between Kindergarten and 3rd Grade and had at least five years of teaching experience.

Table 5

Professional Characteristics of Elementary Teachers (n = 164)

Characteristic	*n*	%
Grade Level Taught		
Kindergarten	35	21.34
Grade 1	30	18.29
Grade 2	32	19.51
Grade 3	30	18.29
Grade 4	19	11.59
Grade 5	25	15.24
Grade 6	13	7.93
Multiple Grades	14	8.54
Grade Band Taught		
Early Elementary (K-2)	90	52.63
Middle Elementary (3-4)	46	26.90
Late Elementary (5-6)	35	20.47
Years of Teaching Experience		
1-5	31	18.79
6-10	32	19.39
11-15	36	21.82
16-20	26	15.76
21-25	12	7.27
26-30	16	9.70
31+	12	7.27

The ESMIRC survey also collected teaching and learning information for science and mathematics separately including teacher's professional development involvement over the past two years, number of lessons taught in a month (i.e., four-week period), and the type of instruction used in lessons. There were differences between teachers' instruction for science and mathematics in both the number of lessons provided as well as the type of instruction provided (Table 6). When asked how many lessons teachers provided per month, a majority of teachers reported fewer than two science lessons per week (n = 92, 56.1%) compared to more than 12 mathematics lessons per week (n = 132, 80.5%). In science lessons, more teachers reported integrating science instruction with other subjects as opposed to teaching it independently (n = 110, 67.5% and n = 94, 57.7%, respectively). In contrast, teachers reported teaching almost all of their mathematics lessons independent of other subjects (n = 147, 90.2%) with less than one-third of teachers reporting their lessons being integrated with other subjects (n = 49, 30.1%). Additionally, a majority of teachers participated in up to ten hours of professional development in the past two years in both science and mathematics (n = 96, 58.5%; n = 93, 56.7%, respectively). Overall, a majority of teachers maintained their professional development in both science and mathematics whereas lessons and instruction differed in that science lessons occurred less frequently and were integrated with other subjects compared to mathematics lessons which occurred more frequently and were taught independently from other subjects.

Table 6

Elementary Teachers' Teaching and Learning Experiences (n = 164)

Experience	Science		Math	
	n	%	*n*	%
Professional Development Participation				
0 hours	36	22.0	25	15.2
1-5 hours	63	38.4	55	33.5
6-10 hours	33	20.1	38	23.2
11-15 hours	10	6.1	19	11.6
16-20 hours	11	6.7	14	8.5
21-25 hours	3	1.8	5	3
26-30 hours	2	1.2	4	2.4
30+ hours	6	3.7	4	2.4
Number of Lessons per Month				
0 lessons	5	3.0	0	0.0
1-2 lessons (around 1 every other week)	42	25.6	1	0.6
4 lessons (around 1 per week)	45	27.4	7	4.3
5-8 lessons (around 2 per week)	37	22.6	7	4.3
9-12 lessons (around 3 per week)	26	15.9	17	10.4
More than 12 lessons	9	5.5	132	80.5
Type of Instruction Provided				
Subject taught independently	94	57.7	147	90.18
Subject integrated with other subjects	110	67.5	49	30.06
Both independently and integrated	41	25.2	32	19.63
Specialist provides instruction	0	0.0	0	0.00
Another teacher provides instruction	0	0.0	1	0.61
Other teaching	4	2.5	0	0.00
Missing	1	0.6	0	0.00

Note. Reported professional development participation took place over the past two years.

Confirmatory Factor Analysis of Conceptual Framework

Prior to analysis, data behavior was screened to make sure the confirmatory factor analysis (CFA) specified the correct model based on data characteristics. Skewness and kurtosis for all science and mathematics items were within recommended thresholds (i.e., skewness < 2 and kurtosis < 7) (Chou & Bentler, 1995; Curran et al., 1996). Polychoric correlations were evaluated to determine if any items had weak correlations (i.e., < 0.3) and warranted removal prior to the CFA. All instructional reform capacity items had correlations greater than 0.3 and were retained in the CFA model.

Confirmatory factor analyses were performed on the 51 instructional reform capacity items for science and mathematics independently to examine whether they fit the proposed five factors aligned with the conceptual model (i.e., dimensions of instructional reform capacity) used in this study (see Figure 3, Chapter 2). The 5-factor CFA, based on the theoretical underpinnings of the conceptual framework were analyzed using M*plus* 8.7 software (Muthén & Muthén, 2021). The specified model allowed relationships between factors and accounted for the ordinal nature of the data.

Model fit indices were evaluated from CFA models of the ESMIRC instructional reform capacity items for science and mathematics (see Table 7). The chi-square values for science ($\chi^2(1214) = 2266.10$, $p < .001$) and mathematics ($\chi^2(1214) = 2123.29$, $p < .001$) rejected the null hypothesis of a perfect model fit. While this may be an indicator of poor model fit, the chi-square test statistic is sensitive to sample sizes and non-normal data and should not be the only fit statistic used to evaluate the CFAs (Brown, 2015). In addition to the Chi-square statistic, the standardized root mean square residual (SRMR) was evaluated for model fit. The SRMR ranges from 0.0 to 1.0 with 0.0 indicating a perfect fit with a SRMR ≤ 0.08 indicating an acceptable model fit (Hu & Bentler, 1999). While the model of the science items had an acceptable model fit (SRMR = 0.08), the model of the mathematics items did not (SRMR = 0.09).

Additional fit indices were used to determine the overall characteristics of the model. The root mean squared error of approximation (RMSEA) was used to evaluate the model's ability to fit the data with the fewest number of factors. Browne and Cudeck (1993) recommend RMSEA ≤ 0.05 to indicate a close fit and values between 0.05 and 0.08 to indicate a fair fit. RMSEA values of both science and mathematics items (0.073 and 0.068, respectively) indicated a fair fit. Lastly, comparative fit indices were used to evaluate the fit of the user-specified model to a baseline model. A Comparative Fit Index (CFI) of greater than or equal to 0.95 is often considered an acceptable fit. With the Tucker Lewis Index (TLI), Hu and Bentler (1999) recommend values greater than 0.95 and Bentler and Bonnett (1980) suggest indices lower than 0.90 represent an inadequate fit. Both indices for the science (CFI = 0.90, TLI = 0.90) and mathematics (CFI = 0.90, TLI = 0.89) models suggest less than adequate fit. The lack of acceptable fit present in these indices suggested an alternative model may represent the instructional reform capacity data collected in this study better and warranted further analysis through exploratory factor analysis.

Table 7

Goodness-of-Fit Indices for CFA 5-Factor Models

Model	Chi Square	df	SRMR	RMSEA (90% CI)	CFI	TLI
Science	2266.10*	1214	0.082	0.073 (0.068 0.077)	0.898	0.893
Math	2123.293*	1214	0.086	0.068 (0.063 0.072)	0.896	0.891

Note. **p* < .001; SRMR = Standardized Root Mean Square Residual; RMSEA = Root Mean Square Error of Approximation; CI = Confidence Interval; CFI = Comparative Fit Index; TLI = Tucker Lewis Index

Developing a New Model to Represent the Data

In order to better understand the underlying structures of the data as well as the nature of the relationships between the items with these structures, exploratory factor analyses (EFA) were performed on the science and mathematics instructional reform capacity items independently of one another. Parallel analysis was used to determine the number of factors to extract instead of the Kaiser criterion (i.e., eigenvalues greater than one) because the Kaiser criterion has been known to overestimate the number of factors (Velicer & Jackson, 1990). The EFA model used an oblique rotation (i.e., geomin), a robust estimator to ordinal data (i.e., weighted least squares mean and variance (WLSMV)), and identified missing and categorical data (Brown, 2015; Muthén & Muthén, 1998-2017). Model fit statistics were compared across multiple factor models for both science and mathematics. The models with the recommended number of factors from the parallel analysis had the best fit statistics.

Exploratory Factor Analyses

In order to develop a model that was parsimonious, internally consistent, and functional, factor loadings from the EFAs were evaluated. Items with factor loadings less than 0.4 were removed because of their limited contribution to the variation within the factors. Additionally, items that loaded on multiple factors (i.e., cross-loaded) were also removed (Boateng et al., 2018). Based on these recommendations, seven items were identified for removal from each subject, science and mathematics, of instructional reform capacity items. While most of the items removed were not the same across the two subjects, two items removed overlapped including “I use technology effectively to support students in building their knowledge” and “There is sufficient technology to provide students with opportunities for learning (for example: computers, Wi-Fi, Google Classroom, SeeSaw).” After removal of the items, the mathematical structure of both science and mathematics instructional reform capacity indicated seven underlying factors; however, the items did not load on similar factors across science and mathematics. The underlying factors (i.e., dimensions) are found in Table 8.

Table 8

Dimensions of Instructional Reform Capacity for Science and Mathematics

Dimension	# Items	*M*	*SD*	*α*
Science				
Pedagogical Content Knowledge	4	4.74	0.80	0.824
Professional Learning	3	5.13	0.71	0.760
Leadership	13	4.07	1.03	0.937
Policy	6	4.13	1.01	0.845
Culture	5	5.02	0.75	0.773
Social	7	4.63	1.00	0.909
Structure	6	4.03	1.04	0.836
Mathematics				
Pedagogical Content Knowledge	4	5.22	0.62	0.801
Professional Learning	6	4.88	0.70	0.770
Leadership	4	4.86	0.86	0.838
Policy	6	5.01	0.71	0.800
Social-Cultural	9	5.08	0.71	0.892
Instructional Structures	7	4.41	0.94	0.856
Professional Learning Structures	8	3.95	0.99	0.880

The underlying dimensions of science instructional reform capacity consisted of pedagogical content knowledge (PCK), professional learning, leadership, policy, culture, social, and structure (Table 8). Expertise items were present in both pedagogical content knowledge as well as the professional learning dimensions. Professional learning included items like “I am committed to learning new knowledge and skills for science teaching and learning" whereas pedagogical content knowledge included items like "I plan science instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity." The leadership dimension had the greatest number of items including "My administrators clearly communicate the importance of science instruction." Cronbach alpha values for all of the dimensions were considered acceptable with values ranging from 0.760 to 0.937 (Cronbach, 1951).

The underlying dimensions of instructional reform capacity for mathematics consisted of PCK, professional learning, leadership, policy, social-cultural, instructional structures, and professional learning structures (Table 8). Professional learning included similar items to science and also included "Conversations with my administrator(s) has made me rethink or adjust my mathematics teaching." PCK had the same items for mathematics instruction as science instruction. The structural dimensions of instruction and professional learning differed in their focus. The instructional structures focused on structures involved in classroom learning like "Materials for mathematics instructional activities are accessible (for example: books, supplies)" whereas professional learning structures aligned with professional learning like "There is sustained investment focused on mathematics teaching and learning for teachers (for example: professional development, training, support, materials)." All of the dimensions had acceptable Cronbach alpha values ranging from 0.770 to 0.892 (Cronbach, 1951).

Confirmatory Factor Analyses on New Dimensions

Following the exploratory factor analysis and item reduction process, CFAs were performed on the instructional reform capacity items for science and mathematics independently of one another. Similar to prior models, the model used an oblique rotation (i.e., geomin), a robust estimator to ordinal data (i.e., weighted least squares mean and variance (WLSMV)), and identified missing and categorical data (Brown, 2015; Muthén & Muthén, 1998-2017).

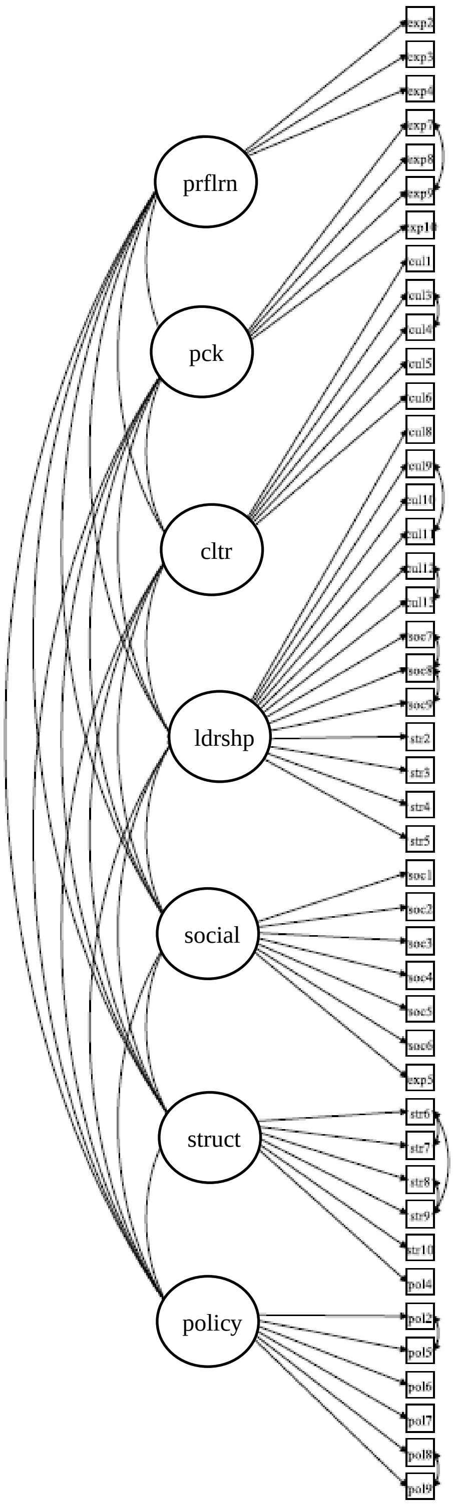
Instructional Reform Capacity for Science

The fit statistics for the CFA model of the instructional reform items for science indicated a model with a fair fit ($\chi^2(881) = 1606.73$, $p < .001$, SRMR = 0.072, RMSEA = 0.071, CFI = 0.922, and TLI = 0.916). Modification indices were used to improve model fit, allowing for error covariances between items loading on to the same dimension. For example, “Science assessment tasks (for example: tests, quizzes, projects, etc.) are mandated (required)” and “Science lessons and activities/labs are mandated (required)” both loaded onto the policy dimension for science and were allowed to covary. Due to the integrated nature of both the dimensions and items for instructional reform, allowing these covariances made sense and did not undermine the validity of the survey. A total of 11 pairs of items were allowed to covary. These modifications to the model, improved the fit of the model ($\chi^2(870) = 1379.64$, $p < .001$, SRMR = 0.066, RMSEA = 0.060, CFI = 0.945, and TLI = 0.941). The final model can be found in Figure 4.

The final model of instructional reform capacity for science found multiple dimensions to be highly related. Strong correlations were found between leadership and the dimensions of culture, structure, social, and policy (.69, .75, .73, and .83, respectively). In addition, strong correlations were found between the social and culture dimensions and between the policy and structure dimensions (.66 and .87, respectively).

Figure 4

CFA Model of Instructional Reform Capacity for Science



Legend
- prflrn = professional learning
- pck = pedagogical content knowledge
- cltr = culture
- ldrship = leadership
- social = social
- struct = structure
- policy = policy

The final model of instructional reform capacity for science had acceptable loadings. The factor loadings for each of the dimensions can be found in Table 9. The average factor loading across all of the dimensions was 0.75. Additionally, internal consistency of the dimensions was measured using Cronbach's alpha, in which a score of 0.70 is considered acceptable with scores of 0.80 and higher preferred (Cronbach, 1951). The dimensions of professional learning and culture had acceptable alpha coefficients (0.76 and 0.77, respectively) with the remaining dimensions of pedagogical content knowledge, leadership, policy, social, and structure having alphas above 0.80 (0.82, 0.94, 0.85, 0.91, and 0.84, respectively). Overall, the model statistics and internal consistencies supported the creation of factors scores for the dimensions using averages addressed later in the results.

Table 9

Results from a CFA of Instructional Reform Capacity in Science (n = 164)

Dimensions & Items	Factor Loading
Pedagogical Content Knowledge (*M* = 4.74, *SD* = .80, *α* = .824)	
I am knowledgeable about the ___________ content I am expected to teach.	0.56
I plan ___________ instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity.	0.82
I have sufficient ___________ expertise to respond to the challenges faced by students from diverse backgrounds and language or ability proficiencies.	0.71
I use instructional strategies that enable students to build/construct their own knowledge in ___________.	0.89
Professional Learning (*M* = 5.13, *SD* = .71, *α* = .760)	
I am committed to learning new knowledge and skills for ___________ teaching and learning.	0.73
My perspective and experience of ___________ teaching is valuable in developing a vision for ___________ teaching and learning at my school.	0.89
I am committed to shifting my teaching practices to support student learning in ___________.	0.73
Leadership (*M* = 4.07, *SD* = 1.03, *α* = .937)	
There is a shared vision and a common purpose among teachers focused on ___________ student learning within and across grade levels.	0.76
There is consistency between what my administrators say and what they end up doing for ___________ teaching and learning.	0.69
Professional development focused on __________ teaching and learning is valued in this school.	0.76
My administrators are genuinely attentive to my concerns around curriculum and pedagogy for ___________.	0.80
My administrators clearly communicate the importance of ___________ instruction.	0.83

Dimensions & Items	Factor Loading
My administrators demonstrate high expectations of ___________ learning for all students no matter their background, language or ability proficiencies.	0.76
Conversations with my administrator(s) has made me rethink or adjust my ___________ teaching.	0.73
My administrators meet with me to discuss my ___________ teaching and listen to my needs regarding ___________ instruction and student learning.	0.76
My administrators involve teachers in discussions when developing solutions to meet the needs of ___________ education.	0.83
There is sustained investment focused on __________ teaching and learning for teachers (for example: professional development, training, support, materials).	0.73
Sufficient time is allocated for teachers to develop professionally in __________ teaching and learning (for example: participate in professional discourse, observe one another).	0.66
Programs (for example: professional development, trainings) provided at my school focus on __________ instructional practices.	0.80
Teachers have opportunities for leadership and decision making that impact __________ teaching and learning at the school-level.	0.83
Policy (*M* = 4.13, *SD* = 1.01, α = .845)	
School directives and initiatives are aligned with current state ___________ standards.	0.60
Assessment tasks (for example: tests, quizzes, projects, etc.) used at this school are aligned to ___________ state standards.	0.75
Programs provided at my school (for example: professional development, trainings) support ___________ teaching and student learning.	0.94
Major initiatives provide support and resources for ___________ teaching and student learning.	0.85
___________ assessment tasks (for example: tests, quizzes, projects, etc.) are mandated (required).	0.62
___________ lessons and activities/labs are mandated (required).	0.66

Dimensions & Items	Factor Loading
Culture (*M* = 5.02, *SD* = .75, *α* = .773)	
I have a voice in what happens in my classroom for ___________ teaching and learning (for example: curriculum and instruction).	0.51
It's okay to discuss feelings, worries, and frustrations regarding __________ teaching and learning with other teachers in this school.	0.73
Teachers at this school respect my perspective of ___________ teaching and learning even if we have differing views.	0.73
I am free to participate in professional communities or learning communities focused on __________ teaching and learning as I see fit.	0.69
I am supported by colleagues to try out new ideas in ___________ teaching.	0.84
Social (*M* = 4.63, *SD* = 1.00, *α* = .909)	
I work with colleagues at my school to develop shared meanings of ___________ teaching and student learning.	0.76
I regularly work with other teachers at my school to develop or plan ___________ instruction (for example: goals, objectives, lessons, activities, labs).	0.87
I regularly share and discuss ___________ assessment tasks with other teachers at my school (for example: formative and summative assessments).	0.87
I regularly discuss my ___________ teaching experiences with other teachers at my school (for example: instructional practices, strategies, successes, challenges).	0.90
I regularly engage with other teachers at my school when analyzing students' ___________ work.	0.80
My relationships with other teachers at my school are supportive of my __________ instruction.	0.70
Discussions with a colleague at my school has made me rethink or adjust my ___________ teaching.	0.76

Dimensions & Items	Factor Loading
Structure (*M* = 4.03, *SD* = 1.04, *α* = .836)	
Materials for ___________ instructional activities are accessible (for example: books, supplies).	0.50
There is enough classroom space or facilities (for example: lab space) to support ___________ instruction.	0.50
Learning expectations within and across grade levels for ___________ are cohesive, preventing learning gaps.	0.75
___________ instructional materials used at this school are cohesive.	0.66
The school schedule provides sufficient time to support ___________ instruction and learning for all students.	0.77
Curriculum maps/Pacing guides facilitate ___________ instructional practices that promote student learning in ___________.	0.80

Note. Underscores indicate where the word science was filled in by teachers.

Instructional Reform Capacity for Mathematics

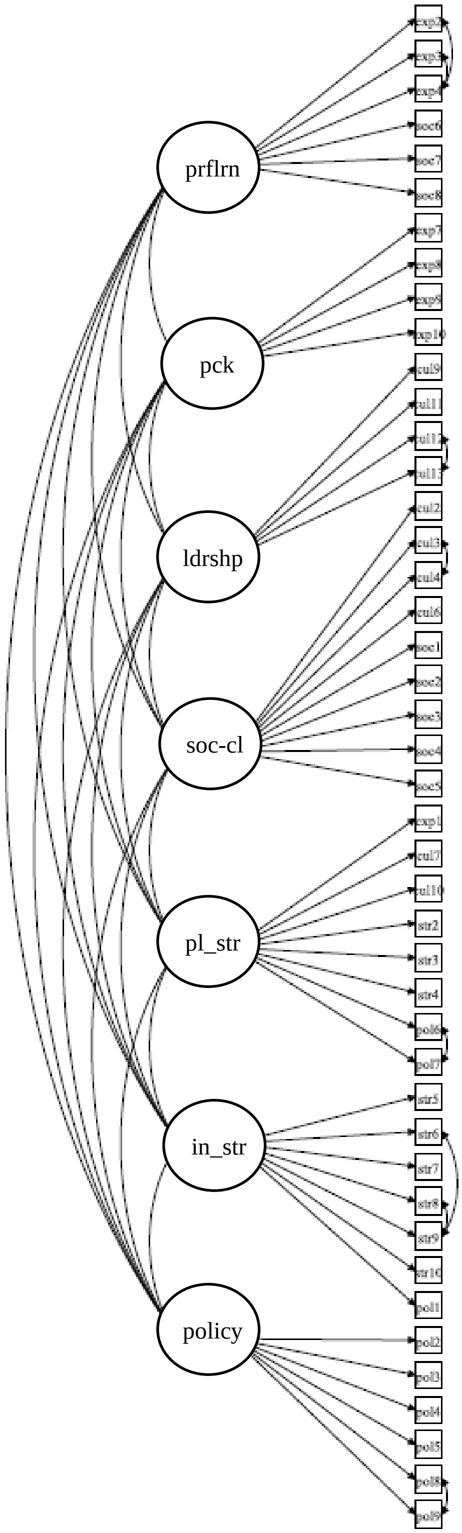
The fit statistics for the CFA model of the instructional reform items for mathematics indicated a model with a fair fit ($\chi^2(881) = 1458.97$, $p < .001$, SRMR = 0.074, RMSEA = 0.063, CFI = 0.927, and TLI = 0.922). Modification indices were used to improve model fit, allowing for error covariances between items loading on to the same dimension. For example, “Materials for mathematics instructional activities are accessible (for example: books, supplies)” and “Mathematics instructional materials used at this school are cohesive” both loaded onto the structure dimension aligned with instruction and were allowed to covary. Due to the integrated nature of both the dimensions and items for instructional reform capacity, allowing these covariances made sense and did not undermine the validity of the survey. A total of eight pairs of items were allowed to covary in this sense. These modifications to the model, improved the fit of the model ($\chi^2(873) = 1275.47$, $p < .001$, SRMR = 0.069, RMSEA = 0.053, CFI = 0.949, and TLI = 0.945). This final model can be found in Figure 5.

The final model of instructional reform capacity for mathematics had dimensions which were highly related. Strong correlations were found between the professional learning structures, instructional structures, and policy dimensions and other dimensions. Professional learning structures was highly correlated with several dimensions including professional learning, leadership, and social-cultural, policy, and instructional structures (.70, .74, .79, and .83, respectively). Strong correlations were also found between instructional structures and the dimensions of leadership, social-cultural, and policy (.71,

.72, and .79, respectively) as well as between policy and the dimensions of leadership and social-cultural (.70 and .67, respectively).

Figure 5

CFA Model of Instructional Reform Capacity for Mathematics



Legend
prflrn = professional learning
pck = pedagogical content knowledge
ldrshp = leadership
soc-cl = social-cultural
pl_str = professional learning structures
in_str = instructional structures
policy = policy

The final model of instructional reform capacity for mathematics had acceptable loadings. The factor loadings for each of the dimensions can be found in Table 10. The average factor loading across all of the dimensions was 0.73. Additionally, internal consistency of the dimensions was measured using Cronbach's alpha, in which a score of 0.70 is considered acceptable with scores of 0.80 and higher preferred (Cronbach, 1951). The dimensions of professional learning had an acceptable alpha coefficient (0.77) with the remaining dimensions of pedagogical content knowledge, leadership, policy, social-cultural, instructional structures, and professional learning structures having alphas at or above 0.80 (0.80, 0.84, 0.80, 0.89, 0.86, and 0.88, respectively). Overall, the model statistics and internal consistencies supported the creation of factors scores for the dimensions using averages addressed later in the results.

Table 10

Results from a CFA of Instructional Reform Capacity in Mathematics (n = 164)

Dimensions & Items	Factor Loading
Pedagogical Content Knowledge (*M* = 5.22, *SD* = .62, *α* = .801)	
I am knowledgeable about the ___________ content I am expected to teach.	0.64
I plan ___________ instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity.	0.85
I have sufficient ___________ expertise to respond to the challenges faced by students from diverse backgrounds and language or ability proficiencies.	0.80
I use instructional strategies that enable students to build/construct their own knowledge in ___________.	0.80
Professional Learning (*M* = 4.88, *SD* = .70, *α* = .770)	
I am committed to learning new knowledge and skills for ___________ teaching and learning.	0.43
My perspective and experience of ___________ teaching is valuable in developing a vision for ___________ teaching and learning at my school.	0.53
I am committed to shifting my teaching practices to support student learning in ___________.	0.42
Discussions with a colleague at my school has made me rethink or adjust my ___________ teaching.	0.80
Conversations with my administrator(s) has made me rethink or adjust my ___________ teaching.	0.79
My administrators meet with me to discuss my ___________ teaching and listen to my needs regarding ___________ instruction and student learning.	0.92
Leadership (*M* = 4.86, *SD* = .86, *α* = .838)	
There is consistency between what my administrators say and what they end up doing for ___________ teaching and learning.	0.83
My administrators are genuinely attentive to my concerns around curriculum and pedagogy for ___________.	0.88

Dimensions & Items	Factor Loading
My administrators clearly communicate the importance of ___________ instruction.	0.78
My administrators demonstrate high expectations of ___________ learning for all students no matter their background, language or ability proficiencies.	0.70
Policy (*M* = 5.01, *SD* = .71, *α* = .800)	
School directives and initiatives are aligned with current state ___________ standards.	0.81
School policies and initiatives are aligned with instructional practices recommended by a ___________ professional teaching organization (for example: NCTM, NSTA)	0.84
Curriculum maps/Pacing guides facilitate ___________ instructional practices that promote student learning in ___________.	0.72
Assessment tasks (for example: tests, quizzes, projects, etc.) used at this school are aligned to ___________ state standards.	0.73
___________ assessment tasks (for example: tests, quizzes, projects, etc.) are mandated (required).	0.48
___________ lessons and activities/labs are mandated (required).	0.59
Social-Cultural (*M* = 5.08, *SD* = .71, *α* = .892)	
Teachers demonstrate a collective responsibility to improve student learning in ___________ (for example: meet and discuss).	0.69
It's okay to discuss feelings, worries, and frustrations regarding __________ teaching and learning with other teachers in this school.	0.67
Teachers at this school respect my perspective of ___________ teaching and learning even if we have differing views.	0.70
I am supported by colleagues to try out new ideas in ___________ teaching.	0.69
I regularly work with other teachers at my school to develop or plan ___________ instruction (for example: goals, objectives, lessons, activities, labs).	0.82

Dimensions & Items	Factor Loading
I regularly share and discuss ___________ assessment tasks with other teachers at my school (for example: formative and summative assessments).	0.85
I regularly discuss my ___________ teaching experiences with other teachers at my school (for example: instructional practices, strategies, successes, challenges).	0.82
I regularly engage with other teachers at my school when analyzing students' ___________ work.	0.82
My relationships with other teachers at my school are supportive of my __________ instruction.	0.82
Instructional Structures (M = 4.41, SD = .94, α = .856)	
Teachers have opportunities for leadership and decision making that impact __________ teaching and learning at the school-level.	0.86
Materials for ___________ instructional activities are accessible (for example: books, supplies).	0.60
There is enough classroom space or facilities (for example: lab space) to support ___________ instruction.	0.54
Learning expectations within and across grade levels for ___________ are cohesive, preventing learning gaps.	0.76
___________ instructional materials used at this school are cohesive.	0.69
The school schedule provides sufficient time to support ___________ instruction and learning for all students.	0.68
School initiatives support experimentation with ___________ instructional practices.	0.81
Professional Learning Structures (M = 3.95, SD = .99, α = .880)	
I regularly participate in professional development to learn new information and skills for ___________ teaching.	0.46
I have a voice in planning how funds should be used for student's ___________ learning (for example: budgets, supply ordering, grants).	0.60
Professional development focused on __________ teaching and learning is valued in this school.	0.79

Dimensions & Items	Factor Loading
There is sustained investment focused on __________ teaching and learning for teachers (for example: professional development, training, support, materials).	0.83
Sufficient time is allocated for teachers to develop professionally in __________ teaching and learning (for example: participate in professional discourse, observe one another).	0.69
Programs (for example: professional development, trainings) provided at my school focus on __________ instructional practices.	0.90
Programs provided at my school (for example: professional development, trainings) support ___________ teaching and student learning.	0.77
Major initiatives provide support and resources for ___________ teaching and student learning.	0.75

Note. Underscores indicate where the word mathematics was filled in by teachers.

Overall comparison between the fit statistics of the confirmatory factor analysis (CFA) aligned with the conceptual model of this study and the one aligned with the exploratory factor analyses indicated a better model fit with the one aligned with the exploratory factor analyses (Table 11). The decrease of SRMR to be less than or equal to 0.08 indicated an acceptable model fit (Hu & Bentler, 1999). The RMSEA values closer to 0.05 indicate a fair fit but are much closer to the 0.05 Browne and Cudeck (1993) suggest indicates a close fit. Additionally, the comparative fit values of 0.95 for CFI and more than 0.90 for TLI support the seven-factor model as being an acceptable fit for the data. Overall, indices of parsimony (i.e., RMSEA) and comparative fit (i.e., CFI and TLI) improved suggesting the seven-factor model is a better fit with the data.

Table 11

Goodness-of-Fit Indices of CFA Models

Model	Chi Square	df	SRMR	RMSEA	CFI	TLI
5 Factor Model						
Science	2266.10*	1214	0.082	0.073	0.898	0.893
Math	2123.29*	1214	0.086	0.068	0.896	0.891
7 Factor Model						
Science	1379.64*	870	0.066	0.060	0.945	0.941
Math	1275.47*	873	0.069	0.053	0.949	0.945

Note: *p < .001; SRMR = Standardized Root Mean Square Residual; RMSEA = Root Mean Square Error of Approximation; CI = Confidence Interval; CFI = Comparative Fit Index; TLI = Tucker Lewis Index

Instructional Practice Use in Science and Mathematics

To address the first research question, regarding elementary teachers' instructional practice use for science and mathematics instruction, descriptive statistics were utilized to evaluate teachers reported use of instructional practices during their science and mathematics lessons, respectively. To compare instructional practice use between science and mathematics, t-tests were used to compare the average use of elementary teachers.

Science Instructional Practices

Across the sample of 164 elementary teachers, there was a pattern of instructional practices commonly used in science instruction. The most common instructional practices were reportedly used by almost two-thirds of teachers in most or every lesson. These instructional practices included direct instruction (72%), open-ended questions to stimulate whole class discussions (68%), concepts to explain natural events or real-world phenomena (67%), group discussions where students make sense of concepts (66%), and teaching vocabulary before a lesson (65%).

Contrastingly, instructional practices reported to be used the least were used by less than one-third of teachers in most or every lesson. Instructional practices used the least included students developing a conceptual model based on data or observations (e.g., graphs to display data) (17%), comparing multiple representations of solving a problem (20%), respectfully critiquing each other's reasoning (21%), displaying and analyzing data (26%), practicing for tests (29%), using computers calculators, or other technology to learn concepts (30%), and reflecting on their work (32%). Table 12 shows the descriptive statistics for instructional practice use reported by elementary teachers during their science lessons.

Table 12

Reported Instructional Practice Use in Science, by Percent

Instructional Practice	*n*	No lessons	A few lessons	About half of lessons	Most lessons	Every lesson
Direct instruction to explain or reinforce ___________ concepts to the whole class	161	2.5	11.2	14.3	32.3	39.8
Group discussions where students make sense of ___________ concepts	163	5.5	14.1	14.7	36.8	28.8
Open-ended questions used to stimulate whole class discussion (most students participate)	163	4.3	11.7	16.0	34.4	33.7
Concepts were used to explain natural events or real-world phenomena	163	6.7	12.9	13.5	42.3	24.5
Vocabulary was taught before the lesson	161	6.8	11.2	16.8	39.1	26.1
Activity sheets were used to reinforce skills and content	162	6.8	15.4	27.2	34.0	16.7
Students practiced for tests	162	42.0	22.2	7.4	21.0	7.4
Computers, calculators, or other technology were used to learn concepts	160	23.8	28.1	18.1	22.5	7.5
Equipment, measuring tools, or manipulatives were used in problem-solving/investigations	163	13.5	22.1	22.7	30.7	11.0
Textbooks, fiction or nonfiction books, or other materials (for example: reading passages/sections, newsletters) were read in class, either aloud or silently	163	6.7	19.0	17.8	37.4	19.0

Instructional Practice	*n*	No lessons	A few lessons	About half of lessons	Most lessons	Every lesson
A conceptual model was developed based on data or observations (model is not provided by textbook or teacher) (for example: graphs and data displays)	162	34.6	30.2	17.9	14.8	2.5
A drawing or model (3-D, conceptual) of a concept or process was created (for example: a drawing of the solar system, model of a cell, using manipulatives to model addition, area or array model for multiplication)	160	24.4	25.0	18.1	28.8	3.8
An investigation or experiment was performed (for example: hands-on, virtual, simulations)	162	9.3	30.2	24.7	27.2	8.6
Multiple representations of solving a problem were compared (for example: numbers, tables, graphs, pictures)	159	25.8	30.8	23.9	17.0	2.5
Methods for solving a problem were explained or justified	157	14.6	22.9	17.2	31.8	13.4
Students collected data or information	161	17.4	29.8	18.6	28.0	6.2
Students displayed and analyzed data	159	20.8	32.1	21.4	19.5	6.3
Students had to explain their reasoning and/or supply evidence to support a claim or explanation	161	11.2	27.3	20.5	27.3	13.7
Students respectfully critiqued each other's reasoning	161	32.9	29.2	16.8	16.8	4.3
Students reflected on their work in class or for homework (for example: in their journals)	160	31.3	21.3	15.6	25.0	6.9

In understanding how reported instructional practice use aligns with the current framework of effective science teaching and learning, the instructional practices were compared to the four interconnected strands of proficiency endorsed by the National Research Council (NRC) (National Research Council (NRC), 2007; National Research Council [NRC], 2008). The NRC's framework (2008) recognizes "science as a both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge" (p. 17) and consists of the four strands presented in Table 13.

Table 13

Proficiency Strands of Effective Science Teaching and Learning

Strand	Description
Understanding scientific explanations	understanding the interrelations among central scientific concepts and using them to build and critique scientific arguments
Generating scientific evidence	knowledge and skills needed to build and refine models and explanations, design and analyze investigations, and construct and defend arguments with evidence
Reflecting on scientific knowledge	how evidence and arguments based on scientific knowledge that is constructed
Participating productively in science	skillful participation in a scientific community in the classroom and mastery of productive ways of presenting ideas, using scientific tools, and interacting with peers about science

Instructional practices for science more commonly reported by teachers aligned more with teacher-centered instruction. More teachers reported explaining or reinforcing concepts through direct instruction, using open-ended questions to stimulate whole group discussion, and using textbooks or other readings in more than half of their lessons (72%, 68%, and 56%, respectively). About two-thirds of teachers reported using group discussions and making connections to natural events and real-world phenomena in at least most of their science lessons (66% and 67%, respectively). While these are typically enacted in more teacher-centered settings, these instructional practices do align with the strands and can assist in establishing the foundational knowledge needed for science proficiency.

Overall, fewer teachers reported using reform-oriented (i.e., student-centered) instructional strategies aligned with the strands for proficiency in science learning in more than half of their science lessons. For example, about one-third of teachers reported students performing an investigation or experiment, collecting data or information, creating a drawing of a model of a concept or process, reflecting on their work, or using technology to understand a concept in more than half of their lessons (36%, 34%, 33%, 32%, and 30%, respectively). Less than one-quarter of teachers reported having students critiquing each other's reasoning or developing a conceptual model based on data and observations in more than half of their lessons (21% and 17%, respectively). While not the more prominent instructional strategies, the use of these instructional practices promoting science learning indicated teachers used a diversity of instructional practices in their classroom.

Teachers reported using instructional strategies incorporating multiple strands of science proficiency irregularly with some being used more frequently and others less frequently. For example, almost half of the teachers surveyed reported having students explain or justify their methods for solving a problem (45%) or explain their reasoning and/or supply evidence to support a claim or explanation (41%) in more than half of their lessons. Contrastingly, less than one-third of teachers reported having students compare multiple representations of solving a problem (20%) or having students display and analyze data (26%) in more than half of their lessons. Overall, teachers reported using instructional practices integrating multiple strands of science proficiency unevenly.

Mathematics Instructional Practices

Instructional practices reportedly used by the 164 teachers in their mathematics instruction indicated some practices being used more than others. Almost all of the teachers reported using direct instruction to explain or reinforce concepts in most or every lesson (93%). Additional instructional strategies reportedly used most or every lesson included methods for solving a problem being explained or justified (85%), activity sheets being used to reinforce skills and content (84%), vocabulary being taught before the lesson (76%), and group discussions in which students make sense of mathematic concepts (73%). Moreover, teachers reported using open-ended questions to stimulate whole class discussions (69%) and comparing multiple representations of solving problems (64%).

In contrast, instructional practices used the least were used by less than one-third of teachers in most or every lesson. These included students displaying and analyzing data (31%), collecting data or information (32%), developing a conceptual model based on data or observations (33%), and respectfully critiquing each other’s reasoning (33%). Table 14 shows the descriptive statistics for instructional practice use reported by elementary teachers during their mathematics lessons.

Table 14

Reported Instructional Practice Use in Mathematics, by Percent

Instructional Practice	*n*	No lessons	A few lessons	About half of lessons	Most lessons	Every lesson
Direct instruction to explain or reinforce ___________ concepts to the whole class	162	0.0	1.9	4.9	34.0	59.3
Group discussions where students make sense of ___________ concepts	162	3.1	12.3	11.7	38.3	34.6
Open-ended questions used to stimulate whole class discussion (most students participate)	163	4.3	12.9	14.1	38.7	30.1
Concepts were used to explain natural events or real-world phenomena	162	13.6	12.3	13.6	45.1	15.4
Vocabulary was taught before the lesson	162	3.1	9.3	11.7	45.7	30.2
Activity sheets were used to reinforce skills and content	161	1.9	5.6	8.7	35.4	48.4
Students practiced for tests	160	9.4	23.1	10.0	30.0	27.5
Computers, calculators, or other technology were used to learn concepts	160	13.8	26.9	15.6	28.7	15.0
Equipment, measuring tools, or manipulatives were used in problem-solving/investigations	161	7.5	13.0	21.1	39.1	19.3
Textbooks, fiction or nonfiction books, or other materials (for example: reading passages/sections, newsletters) were read in class, either aloud or silently	162	19.1	26.5	9.9	29.0	15.4
A conceptual model was developed based on data or observations (model is not provided by textbook or teacher) (for example: graphs and data displays)	159	23.3	26.4	17.0	25.2	8.2

Instructional Practice	*n*	No lessons	A few lessons	About half of lessons	Most lessons	Every lesson
A drawing or model (3-D, conceptual) of a concept or process was created (for example: a drawing of the solar system, model of a cell, using manipulatives to model addition, area or array model for multiplication)	160	11.3	19.4	13.8	41.9	13.8
An investigation or experiment was performed (for example: hands-on, virtual, simulations)	157	19.1	22.9	17.2	31.8	8.9
Multiple representations of solving a problem were compared (for example: numbers, tables, graphs, pictures)	160	3.1	7.5	25.0	43.8	20.6
Methods for solving a problem were explained or justified	156	0.6	3.8	10.3	50.6	34.6
Students collected data or information	160	25.6	22.5	20.0	20.0	11.9
Students displayed and analyzed data	160	25.6	21.3	21.9	22.5	8.8
Students had to explain their reasoning and/or supply evidence to support a claim or explanation	161	6.8	11.2	24.2	36.0	21.7
Students respectfully critiqued each other's reasoning	161	28.0	16.1	23.0	22.4	10.6
Students reflected on their work in class or for homework (for example: in their journals)	160	25.0	17.5	15.0	31.9	10.6

To examine how reported instructional practice use aligned with effective mathematics teaching and learning for mathematics proficiency, the instructional practices were compared to the five interconnected strands of proficiency (Table 15) endorsed by the National Research Council (NRC) and National Council of Teachers of Mathematics (NCTM) (National Council of Teachers of Mathematics [NCTM], 2014; National Research Council [NRC], 2001). According to NCTM (2014), these strands incorporate the mathematical practices representing what students do as they learn mathematics with the mathematics teaching practices consisting of "high-leverage practices and essential teaching skills necessary to promote deep learning of mathematics" (p. 9). This framework "supports the characterization of mathematics learning as an active process, in which each student builds his or her own mathematical knowledge from personal experiences, coupled with feedback from peers, teachers and other adults, and themselves" (p. 9).

Instructional practices for mathematics most commonly reported by teachers aligned more with teacher-centered instruction. For example, more than three-quarters of teachers reported using direct instruction, activity sheets, and front-loading vocabulary in more than half of their lessons (93%, 84%, and 76%, respectively). These instructional practices are typically present in more teacher-centered settings; however, they can assist in establishing conceptual understanding which is essential for more advanced mathematical proficiency skills like procedural fluency.

Table 15

Strands of Mathematical Proficiency for Teaching and Learning

Strand	Description
Conceptual understanding	The comprehension and connection of concepts, operations, and relations. For example, being able to represent mathematical situations in different ways and knowing how different representations can be useful for different purposes.
Procedural fluency	The knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly, accurately, and efficiently. Methods include written procedures, mental methods for finding certain sums, differences, products, or quotients, as well as methods that use calculators, computers, or manipulative materials such as blocks, counters, or beads.
Strategic competence	The ability to formulate, represent, and solve mathematical problems. Students learn how to form mental representations of problems, detect mathematical relationships, and devise novel solution methods when needed.
Adaptive reasoning	The capacity to think logically about the relationships among concepts and situations. Reasoning stems from careful consideration of alternatives, and includes knowledge of how to justify the conclusions.
Productive disposition	The tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics.

Other instructional practices teachers reported using frequently align with the teaching and learning strands and are more student-centered. For example, almost all teachers (85%) reported having students explain or justify their methods for solving a problem in more than half of their lessons. Less common instructional practices reportedly used but still utilized by a majority of teachers in more than half of their lessons included students being engaged in group discussions to make sense of mathematical concepts and being provided open-ended questions to stimulate discussion (73% and 69% of teachers, respectively). Teachers reported using more student-centered instructional practices in more than half of their mathematics lessons.

Reinforcing the interwoven nature of the strands, NRC and NCTM advocate for the strands of mathematical proficiency to be developed in synchrony with one another. Examination of instructional practices incorporating multiple strands indicated they were not used consistently within the sample of surveyed teachers. Some instructional practices were reportedly used in more than half of the lessons by a majority of the teachers including students comparing multiple representations of solving a problem and students explaining their reasoning or supplying evidence to support a claim or explanation (64% and 58% of teachers reported using, respectively). Contrastingly, less than half of teachers reported having students respectfully critique each other's reasoning, and reflect on their work in more than half of their lessons (33% and 42%, respectively). Overall, teachers reported using instructional practices leveraging multiple strands of mathematically proficiency inconsistently across their lessons, using some more than others.

Comparing Instructional Practice Use in Science and Mathematics

In order to address the third part of my first research question, comparing the difference between instructional practice use in science and mathematics, paired t-tests were performed between the instructional practices. Given the ordinal nature and sample size of the data, t-tests are more robust to the violations of the assumptions underlying their use allowing them to provide appropriate findings for comparison. Table 16 provides the descriptive statistics and results of the paired samples t-tests for science and mathematics instructional practice use reported by elementary teachers.

Table 16

Reported Instructional Practice Use, by Subject

Instructional Practice	*n*	Science		Mathematics		t-value
		M	*SD*	*M*	*SD*	
Direct instruction to explain or reinforce ___________ concepts to the whole class	160	3.95	1.103	4.50	0.682	-7.425***
Group discussions where students make sense of ___________ concepts	162	3.69	1.192	3.89	1.109	-2.435*
Open-ended questions used to stimulate whole class discussion (most students participate)	163	3.82	1.151	3.77	1.140	0.505
Concepts were used to explain natural events or real-world phenomena	162	3.65	1.182	3.36	1.270	2.736**
Vocabulary was taught before the lesson	160	3.66	1.181	3.92	1.181	-3.723***
Activity sheets were used to reinforce skills and content	160	3.38	1.143	4.23	0.958	-10.603***
Students practiced for tests	159	2.28	1.392	3.43	1.357	-11.865***
Computers, calculators, or other technology were used to learn concepts	159	2.63	1.271	3.04	1.312	-4.095***
Equipment, measuring tools, or manipulatives were used in problem-solving/investigations	161	3.02	1.230	3.50	1.163	-4.433***
Textbooks, fiction or nonfiction books, or other materials (for example: reading passages/sections, newsletters) were read in class, either aloud or silently	162	3.44	1.190	2.95	1.396	4.621***
A conceptual model was developed based on data or observations (model is not provided by textbook or teacher) (for example: graphs and data displays)	159	2.21	1.149	2.69	1.298	-5.458***

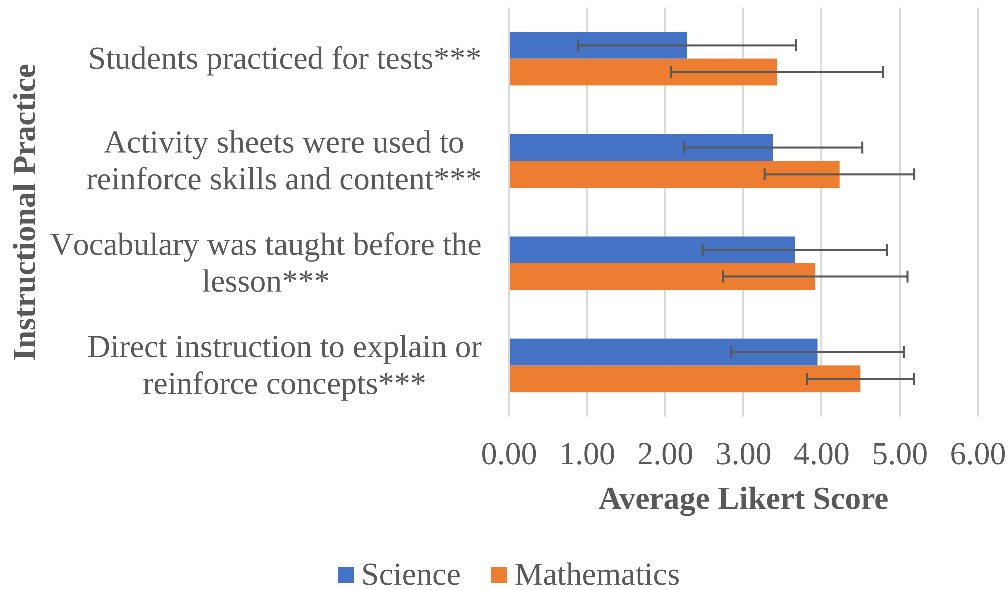
Instructional Practice	*n*	Science		Mathematics		t-value
		M	*SD*	*M*	*SD*	
A drawing or model (3-D, conceptual) of a concept or process was created (for example: a drawing of the solar system, model of a cell, using manipulatives to model addition, area or array model for multiplication)	158	2.63	1.243	3.27	1.240	-7.147***
An investigation or experiment was performed (for example: hands-on, virtual, simulations)	157	2.98	1.146	2.89	1.291	0.847
Multiple representations of solving a problem were compared (for example: numbers, tables, graphs, pictures)	157	2.39	1.125	3.71	0.981	-14.515***
Methods for solving a problem were explained or justified	155	3.07	1.290	4.15	0.804	-11.918***
Students collected data or information	159	2.76	1.219	2.70	1.363	0.653
Students displayed and analyzed data	157	2.59	1.203	2.67	1.317	-0.865
Students had to explain their reasoning and/or supply evidence to support a claim or explanation	160	3.06	1.237	3.54	1.154	-5.660***
Students respectfully critiqued each other's reasoning	160	2.31	1.214	2.71	1.363	-5.125**
Students reflected on their work in class or for homework (for example: in their journals)	158	2.56	1.342	2.87	1.387	-3.572***

Note. *M* = mean; *SD* = standard deviation; ***$p < .001$, **$p < .01$, *$p < .05$.

There were many differences between teachers reported use of instructional strategies in their science instruction when compared to their mathematics instruction. Overall, teachers reported more frequent use of instructional practices in their mathematics instruction with the average reported use being higher than those in science for 75% the instructional practices. Furthermore, almost all of these differences were statistically significant. For example, comparison of multiple representations of solving a problem and explanation or justification of methods for solving a problem were statistically more prevalent in mathematics instruction as compared to science. Additionally, the use of activity sheets to reinforce skills and content as well as practicing for tests were used statistically more in mathematics instruction compared to science (Figure 6).

Figure 6

Reported Use of Teacher-Centered Instructional Practices, by Subject

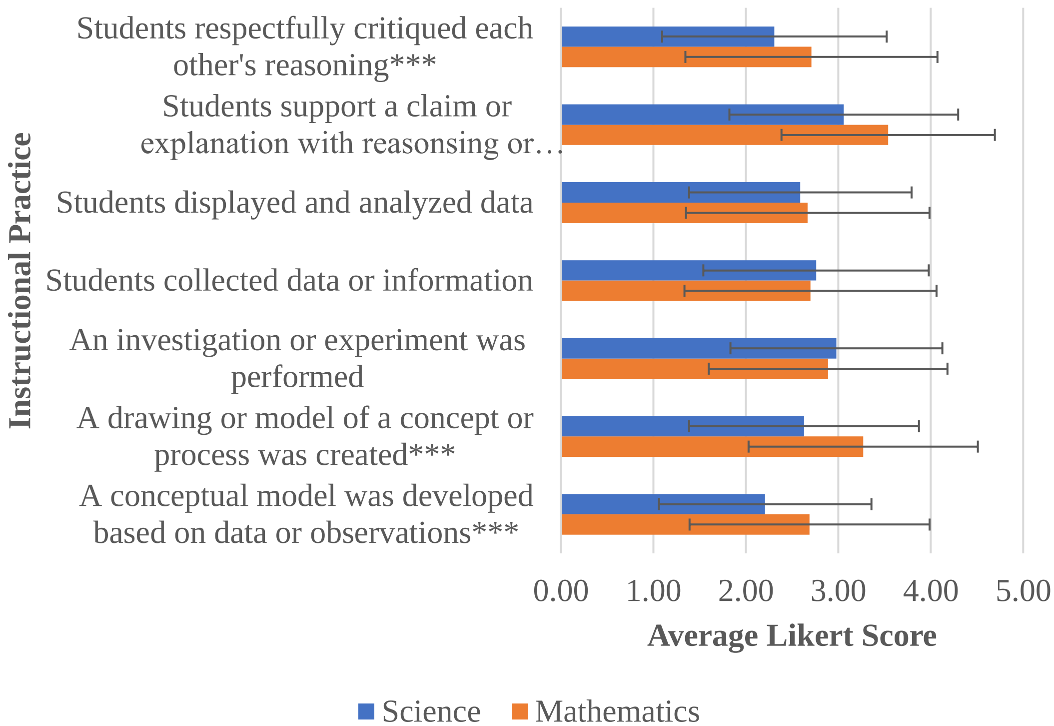


Note. 5-point Likert score ranged from *no lessons* (0) to *all lessons* (5). Error bars show standard deviation. ***$p < .001$

In fact, the only instructional practice used significantly more in science compared to mathematics was the use of textbooks or other materials in class. While teachers reported students' performing experiments or investigations as well as collecting data more frequently in science instruction, their use was not significantly different from that of mathematics instruction (Figure 7). Overall, more instructional practices were used significantly more frequently in mathematics instruction when compared to science instruction.

Figure 7

Reported Use of Reform-Oriented Instructional Practices, by Subject



Note. 5-point Likert score ranged from *no lessons* (0) to *all lessons* (5). Error bars show standard deviation. ***$p < .001$

To further examine the relationship teacher-centered versus reform-oriented instructional practices, composites were created for the two types of teaching practices. The composite measures were based off factor analyses from other research and tested for their reliability using coefficient alpha. Table 17 shows the teacher-centered and reform-oriented (i.e., student-centered) instructional practices within each composite measure. Reliability measurements for both the teacher-centered and reform-oriented practices composites for both science and mathematics were acceptable with values of

0.674 and 0.841 for science, respectively and 0.656 and 0.830 for mathematics, respectively (Cronbach, 1951).

Table 17

Instructional Practice Composite Measures

Instructional Practices
Teacher-centered practices
Direct instruction to explain or reinforce ___________ concepts to the whole class
Vocabulary was taught before the lesson
Activity sheets were used to reinforce skills and content
Students practiced for tests
Reform-oriented practices
A conceptual model was developed based on data or observations (model is not provided by textbook or teacher) (for example: graphs and data displays)
A drawing or model (3-D, conceptual) of a concept or process was created (for example: a drawing of the solar system, model of a cell, using manipulatives to model addition, area or array model for multiplication)
An investigation or experiment was performed (for example: hands-on, virtual, simulations)
Students collected data or information
Students displayed and analyzed data
Students had to explain their reasoning and/or supply evidence to support a claim or explanation
Students respectfully critiqued each other's reasoning

There were significant differences between average teacher-centered and reform-oriented composite scores between science and mathematics (Table 18). The scores are averages from a 5-point Likert-scale ranging from *no lessons* (1) to *every lesson* (5). Average scores for teacher-centered practices were higher than student-centered practices in both science and mathematics (3.32 and 2.64 in science, respectively; 4.01 and 2.92 in mathematics, respectively). Additionally, average instructional use was significantly higher for a majority of teacher-centered and reform-oriented instructional practices for mathematics lessons. These composite measures reinforce trends found across the individual instructional practices.

Table 18

Composite Measures for Instructional Practices, by Subject

Composite	Science			Mathematics			t-value
	n	*M*	*SD*	*n*	*M*	*SD*	
Teacher-centered	163	3.32	0.865	162	4.02	0.733	-13.105***
Reform-oriented	161	2.64	0.854	161	2.92	0.907	-4.694***

Note. ***p < .001

Correlations Between Capacity Factors and Instructional Practices

To address the second research question, regarding the relationship between elementary teachers reported instructional reform capacity and their instructional practices, correlations between the factors of instructional reform capacity and the instructional practices were examined for science and mathematics independently of one another and then with one another. Based on the CFAs presented earlier, the factor scores for each dimension of instructional reform capacity were calculated as the average score across the items determined to be part of that dimension (DiStefano et al., 2009). The dimensions used were aligned with the CFAs and differed slightly from the conceptual framework proposed in the literature review. Prior to the correlations and in order to make sure the factor scores and instructional practice scores were on the same scale, the factor scores and instructional practice data were standardized. Due to the ordinal nature of both the factor scores and instructional practice use data, Kendall's tau correlations were performed instead of Pearson Product correlations. Kendall's tau correlations, as compared with Spearman rho correlation coefficient, have been shown to be more representative of the population when a sample size is small and many scores have the same rank (Field, 2013).

Correlations for Science Instruction

Correlations between the dimensions of instructional reform capacity and instructional practices for science instruction indicated the presence of significant correlations that show some interesting patterns. Correlations, as well as their significance, can be found in Table 19. Four dimensions (i.e., pedagogical content knowledge, professional learning, leadership, and policy) were significantly correlated with more than half of the instructional practices in the survey. In addition to significance of correlation, Kendall’s tau correlation values can be interpreted as the strength of a correlation with values less than 0.20 being weak, values between 0.20 and 0.29 as moderate, and values greater than 0.30 as strong (Botsch, 2011). For the most part, correlations are weak; however, both PCK and professional learning have moderate correlations with instructional practices. PCK is moderately correlated with more discussion-based instructional practices (e.g., group discussion, open-ended questions used to stimulate discussions). Professional learning is moderately correlated with multiple instructional practices that are more student-centered (e.g., methods for solving a problem were explained or justified, students respectfully critiqued each other’s reasoning). Furthermore, the instructional practice of performing an investigation was the only one to have strong correlations with any of the dimensions. It was strongly correlated with both policy and structure.

The most highly correlated dimensions with science instructional practices included professional learning and policy. The professional learning dimension was significantly correlated with 16 instructional practices and most significantly correlated ($p < .001$) with instructional practices including students supporting a claim or explanation with reasoning or evidence, critiquing each other's work, explaining or justifying their method for solving a problem, reflecting on their work, and conducting an investigation or experiment which integrated the strands of science proficiency. The policy dimension was significantly correlated with a number of instructional practices including students practicing for tests and activity sheets being used but it was most significantly correlated with students performing an investigation or experiment.

Table 19

Kendall's tau Correlations Between Instructional Reform Capacity Dimensions and Reported Instructional Practice Use in Science

Instructional Practice	PCK	Prof. Learning	Leadership	Policy	Culture	Social	Structure
Direct instruction to explain or reinforce ___________ concepts to the whole class	0.064	0.072	0.010	0.125*	-0.001	0.061	0.082
Group discussions where students make sense of ___________ concepts	0.254***	0.184**	0.103	0.115	0.122*	0.081	0.060
Open-ended questions used to stimulate whole class discussion (most students participate)	0.275***	0.184**	0.093	0.149*	0.168**	0.086	0.071
Concepts were used to explain natural events or real-world phenomena	0.279***	0.162*	0.114	0.157**	0.148*	0.157**	0.073
Vocabulary was taught before the lesson	0.160**	0.144*	0.013	0.090	-0.025	0.037	0.080
Activity sheets were used to reinforce skills and content	0.101	0.089	0.128*	0.173**	0.022	0.142*	0.125*
Students practiced for tests	0.013	0.105	0.103	0.186**	-0.045	0.059	0.120*
Computers, calculators, or other technology were used to learn concepts	0.097	0.149*	0.102	0.133*	0.084	0.057	0.045
Equipment, measuring tools, or manipulatives were used in problem-solving/investigations	0.152*	0.136*	0.154**	0.175**	0.080	0.064	0.123*

Instructional Practice	PCK	Prof. Learning	Leadership	Policy	Culture	Social	Structure
Textbooks, fiction or nonfiction books, or other materials (for example: reading passages/sections, newsletters) were read in class, either aloud or silently	0.158^{*}	0.162^{**}	0.177^{**}	0.180^{**}	0.208^{**}	0.242^{***}	0.146^{*}
A conceptual model was developed based on data or observations (model is not provided by textbook or teacher) (for example: graphs and data displays)	0.114	0.119	$.219^{***}$	0.114	0.010	0.126^{*}	0.125^{*}
A drawing or model (3-D, conceptual) of a concept or process was created (for example: a drawing of the solar system, model of a cell, using manipulatives to model addition, area or array model for multiplication)	0.157^{*}	0.155^{*}	0.144^{*}	0.099	0.019	0.152^{*}	0.111
An investigation or experiment was performed (for example: hands-on, virtual, simulations)	0.184^{**}	0.245^{***}	0.267^{***}	0.317^{***}	0.150^{*}	0.148^{*}	0.302^{***}
Multiple representations of solving a problem were compared (for example: numbers, tables, graphs, pictures)	0.174^{**}	0.178^{**}	0.169^{**}	0.170^{**}	0.012	0.062	0.192^{**}
Methods for solving a problem were explained or justified	0.243^{***}	0.264^{***}	0.186^{**}	0.200^{**}	0.079	0.132^{*}	0.190^{**}
Students collected data or information	0.128^{*}	0.170^{**}	0.179^{**}	0.138^{*}	0.065	0.089	0.140^{*}
Students displayed and analyzed data	0.140^{*}	0.208^{**}	0.252^{***}	0.204^{**}	0.133^{*}	0.159^{**}	0.216^{***}
Students had to explain their reasoning and/or supply evidence to support a claim or explanation	0.178^{**}	0.276^{***}	0.222^{***}	0.145^{*}	0.196^{**}	0.130^{*}	0.117^{*}

Instructional Practice	PCK	Prof. Learning	Leadership	Policy	Culture	Social	Structure
Students respectfully critiqued each other's reasoning	0.109	0.274***	0.178**	0.097	0.089	0.132*	0.067
Students reflected on their work in class or for homework (for example: in their journals)	0.114	0.262***	0.174**	0.141*	0.060	0.131*	0.090

Note. PCK = pedagogical content knowledge, Prof. Learning = professional learning, ***$p < .001$, **$p < .01$, *$p < .05$.

In addition to professional learning and policy, PCK and leadership were significantly correlated with a number of instructional practices but they differed in the types of instructional practices with which they correlated. PCK was most significantly correlated with teacher-centered instructional practices including group discussions, the use of open-ended questions, and the use of science concepts to explain natural events or real-world phenomena. Contrastingly, leadership was most significantly correlated with more student-centered instructional strategies including conceptual models being developed, investigations or experiments being performed, students displaying or analyzing data, as well as students having to explain or support their reasoning with evidence. Leadership was related more significantly with engagement of more student-centered instructional practices aligned with developing science proficiency in students.

The least correlated factors in science instruction were the culture, social, and structural dimensions of instructional reform capacity. Social and culture dimensions correlated most with the use of textbooks or other materials in class. The structural dimension correlated most significantly with investigations or experiments being performed as well as students displaying and analyzing data. The link between these dimensions and instructional practices gives some insight into the role these dimensions play in influencing science instruction.

Correlations for Mathematics Instruction

Correlations between the dimensions of instructional reform capacity and instructional practices for mathematics instruction show some interesting patterns. Correlations as well as their significance can be found in Table 20. Five dimensions (i.e., pedagogical content knowledge, professional learning, policy, instructional structures, and professional learning structures) were significantly correlated with more than half of the instructional practices. In addition to significance of correlation, Kendall's tau correlation values can be interpreted as the strength of a correlation. The professional learning, professional learning structures, instructional structures, and PCK had moderate correlations with multiple teaching practices. PCK correlated more with discussion-based instructional strategies whereas the other dimensions had moderate correlations with some reform-based instructional strategies.

The most highly correlated factors with mathematics instructional practices included professional learning and policy. The professional learning dimension was significantly correlated with 17 instructional practices. It was most significantly correlated ($p < .001$) with instructional practices aligning with students critiquing each other's work, collecting data or information, and supporting a claim or explanation with reasoning or evidence. The policy dimension was significantly correlated with a number of instructional practices including open-ended questions being used to stimulate class discussions and students explaining or justifying their methods for solving a problem but it was most significantly correlated with equipment, measuring tools, or manipulatives used in problem-solving or investigations.

Table 20

Kendall's tau Correlations Between Instructional Reform Capacity Dimensions and Instructional Practice Use in Mathematics

Instructional Practice	PCK	Prof. Learning	Leadership	Policy	Social-Cultural	Instr. Structures	Prof. Learning Structures
Direct instruction to explain or reinforce ___________ concepts to the whole class	0.172*	0.002	0.086	0.152*	-0.010	0.080	-0.031
Group discussions where students make sense of ___________ concepts	0.258***	0.185**	0.205**	0.168**	0.087	0.073	0.157**
Open-ended questions used to stimulate whole class discussion (most students participate)	0.206**	0.193**	0.098	0.198**	0.135*	0.107	0.169**
Concepts were used to explain natural events or real-world phenomena	0.258***	0.187**	0.105	0.172**	0.139*	0.200**	0.162**
Vocabulary was taught before the lesson	0.169**	0.131*	0.101	0.141*	0.062	0.047	0.051
Activity sheets were used to reinforce skills and content	-0.043	0.055	0.090	0.132*	0.057	0.010	-0.030
Students practiced for tests	-0.044	0.098	0.018	0.066	0.089	0.077	0.027
Computers, calculators, or other technology were used to learn concepts	0.100	0.130*	0.065	0.125*	-0.005	0.141*	0.167**
Equipment, measuring tools, or manipulatives were used in problem-solving/investigations	0.198**	0.142*	0.078	0.232***	0.090	0.216***	0.182**

Instructional Practice	PCK	Prof. Learning	Leadership	Policy	Social-Cultural	Instr. Structures	Prof. Learning Structures
Textbooks, fiction or nonfiction books, or other materials (for example: reading passages/sections, newsletters) were read in class, either aloud or silently	0.160*	0.212**	0.117	0.127*	0.117	0.172**	0.218***
A conceptual model was developed based on data or observations (model is not provided by textbook or teacher) (for example: graphs and data displays)	0.076	0.196**	0.044	0.042	0.056	0.135*	0.260***
A drawing or model (3-D, conceptual) of a concept or process was created (for example: a drawing of the solar system, model of a cell, using manipulatives to model addition, area or array model for multiplication)	0.115	0.159*	0.127*	0.177**	0.164**	0.146*	0.187**
An investigation or experiment was performed (for example: hands-on, virtual, simulations)	0.182**	0.198**	0.097	0.192**	0.113	0.207**	0.233***
Multiple representations of solving a problem were compared (for example: numbers, tables, graphs, pictures)	0.159*	0.175**	0.004	0.095	0.057	0.056	0.099
Methods for solving a problem were explained or justified	0.170*	0.178**	0.145*	0.193**	0.132*	0.104	0.095
Students collected data or information	0.069	0.236***	0.085	0.134*	0.157**	0.184**	0.274***

Instructional Practice	PCK	Prof. Learning	Leadership	Policy	Social-Cultural	Instr. Structures	Prof. Learning Structures
Students displayed and analyzed data	0.124^{*}	0.209^{**}	0.114	0.176^{**}	0.141^{*}	0.206^{**}	0.268^{***}
Students had to explain their reasoning and/or supply evidence to support a claim or explanation	0.237^{***}	0.227^{***}	0.116	0.172^{**}	0.181^{**}	0.219^{***}	0.161^{**}
Students respectfully critiqued each other's reasoning	0.109	0.243^{***}	0.075	0.085	0.140^{*}	0.166^{**}	0.179^{**}
Students reflected on their work in class or for homework (for example: in their journals)	0.150^{*}	0.189^{**}	0.058	0.070	0.090	0.190^{**}	0.228^{***}

Note. PCK = pedagogical content knowledge, Prof. learning = professional learning, Instr. Structures = instructional structures, Prof. Learning Structures = professional learning structures, ***p < .001, **p < .01, *p < .05.

In addition to professional learning and policy, professional learning structures, PCK and instructional structures were significantly correlated with a number of instructional practices but they differed in the types of instructional practices with which they correlated. Professional learning and instructional structures were significantly correlated with overlapping instructional practices that were more student-centered. Professional learning structures was highly correlated ($p < .001$) with students working with data by either collecting, analyzing, or displaying it. Instructional structures were significantly correlated with these instructional practices as well but were most significantly correlated with equipment, measuring tools, or manipulatives being used and students supporting a claim using reasoning or evidence. Contrastingly, PCK was most significantly correlated with teacher-centered instructional practices including using mathematical concepts to explain natural events or real-world phenomena and having students make sense of concepts in group discussions. Structural characteristics associated with instruction or professional learning were more strongly related to student-centered instructional practices aligning more with developing mathematics proficiency.

The least correlated dimensions of instructional reform capacity for mathematics instruction were leadership and social-cultural. The social-cultural dimension correlated most highly to students supporting a claim using reasoning or evidence and students creating a model of a concept or process. The leadership dimension correlated most significantly with group discussions being used to help students make sense of concepts. The link between these dimensions and instructional practices gives some insight into the role these dimensions play in influencing mathematics instruction.

Comparing Science and Mathematics Correlations

Some patterns emerged when comparing correlations between instructional reform capacity dimensions and instructional practices between science and mathematics. The factors of professional learning and policy correlated to the highest number of instructional practices within their subject (i.e., science or mathematics). Professional learning was significantly correlated to many overlapping instructional practices across both science and mathematics and was most highly correlated with instructional practices that were more student-centered. For example, professional learning correlated significantly, $p < .001$, with the instructional practices of students supporting a claim or explanation with reasoning or evidence as well as students critiquing each other's reasoning for both science and mathematics.

While professional learning had similar correlation patterns between science and mathematics, correlations between the policy dimension and instructional practices had fewer overlapping relationships between math and science. For example, the policy dimension correlated most significantly with students performing an investigation or experiment in science compared to students using equipment, measuring tools, or manipulatives in problem-solving or investigations in mathematics. In addition, policy correlated with students practicing for tests in science and did not in mathematics whereas policy correlated with students creating a drawing or modeling a concept or process in mathematics and did not in science.

Structural dimensions and PCK had some overlap in their relationships with instructional practices for science and mathematics. The structure dimensions in both science and mathematics (i.e., structure in science and instructional structures and professional learning structures in mathematics) correlated with students performing an investigation or experiment as well as students displaying and analyzing data. In addition, PCK correlated similarly across science and mathematics with significant correlations for both students making sense of concepts in group discussions as well as concepts being used to explain natural events or real-world phenomena.

For both science and mathematics, the dimension(s) aligning with social and cultural instructional reform capacity characteristics were less correlated with reported instructional practice use. The factors did not correlate to similar instructional practices across science and mathematics. In science, the social and culture dimensions correlated with the use of textbooks and other reading materials being used. Contrastingly, in mathematics, the social-cultural dimension correlated with students having to collect data or information. The dimensions did overlap in their relationships with the instructional practices of students using reasoning or evidence to support a claim as well as concepts being used to explain natural events or real-world phenomena.

In addition to correlations between dimensions of instructional reform capacity and individual instructional practices, I performed correlations between the instructional practice composite scores referenced earlier (see Table 18) and the dimensions of instructional reform capacity. In science, the correlations indicated contrasts in their relationships between teacher-centered and reform-oriented instructional practices (Table 21). All of the dimensions of instructional reform capacity were significantly correlated with reform-oriented practices for science. Professional learning, leadership, policy, and structure were moderately correlated, having correlations greater than 0.20, with reform-oriented instructional practices. Contrarily, only policy was moderately correlated with teacher-centered instructional practices in science. Overall, not only were reform-oriented instructional practices significantly correlated with the dimensions of instructional reform, but a majority of them were moderately correlated indicating the potential use of this information to leaders and practitioners in schools for decision making.

Table 21

Correlations Between Dimensions and Instructional Practice Composites, for Science

Dimension	Teacher-centered practices	Reform-oriented practices
PCK	0.105	0.192^{**}
Professional Learning	0.142^{*}	0.269^{***}
Leadership	0.108	0.277^{***}
Policy	0.212^{***}	0.208^{***}
Culture	-0.009	0.125^{*}
Social	0.111^{*}	0.187^{**}
Structure	0.169^{**}	0.215^{***}

Note. PCK = pedagogical content knowledge, $^{***}p < .001$, $^{**}p < .01$, $^{*}p < .05$.

In mathematics, correlations between the instructional practice composite scores and the dimensions of instructional reform capacity expose disparities in their relationships between teacher-centered and reform-oriented instructional practices (Table 22). None of the dimensions of instructional reform capacity were significantly correlated with teacher-centered practices for mathematics. Contrastingly, all of the dimensions with the exception of leadership were significantly correlated with reform-oriented practices. In fact, professional learning, professional learning structures, and instructional structures were strongly correlated with reform-oriented practices (0.360, 0.389, and 0.306, respectively). Additionally, the policy, and social-cultural dimensions were moderately correlated with reform-oriented practices (0.256 and 0.211, respectively).

Table 22

Correlations Between Dimensions and Instructional Practice Composites, for Mathematics

Dimension	Teacher-centered practices	Reform-oriented practices
PCK	0.025	0.189*
Professional Learning	0.123	0.360***
Leadership	0.070	0.141
Policy	0.137	0.256**
Social-Cultural	0.073	0.211**
Professional Learning Structures	0.030	0.389***
Instructional Structures	0.035	0.306***

Note. PCK = pedagogical content knowledge, ***$p < .001$, **$p < .01$, *$p < .05$.

Overall, reform-oriented instructional practices had stronger relationships with the dimensions of instructional reform capacity for both science and mathematics. The stronger correlations between professional learning and structural dimensions for both science and mathematics reveal its potential significant impact on teachers instructional practice use.

CHAPTER 5

DISCUSSION

The purpose of this study was to understand elementary (i.e., K-6) education teachers' teaching and learning experiences related to their science and mathematics instruction. This study consisted of two primary components including (1) the development and validation of a survey instrument, ESMIRC, to measure elementary teachers' instructional reform capacity and instructional practice use pertaining to science and mathematics instruction within the context of their school and (2) the analysis of ESMIRC data to address the research questions. The research questions examined elementary teachers' instructional practice use in science and mathematics as well as the relationship between those instructional practices and the dimensions of instructional reform capacity from the ESMIRC survey.

The discussion of this study is presented in alignment with the two component parts of this study. First, I summarize the findings from the study including the development and validation of the ESMIRC survey, examination of the instructional reform capacity dimensions, and the findings addressing research questions. Next, I describe the limitations of the study and conclude with a discussion on the implications of the study and possible directions for future research.

Findings

ESMIRC Survey Development and Validation

A primary component of this study was the development and validation of a survey focused on the capacity for instructional reform and current instructional practice use. In a review of the literature, limited studies examined the capacity of schools for instructional reform from an ecological perspective (Hayes et al., 2020). Additionally, surveys soliciting instructional practices used in science and mathematics are isolated to a single subject area and rarely compare between subject areas (Hayes et al., 2016; Hopkins et al., 2013; Ross et al., 2003). For example, Hayes and Bae (2016) focused on science instructional practices whereas Shirrell, Hopkins, and Spillane (2019) focused on instructional practices in mathematics. A gap in the literature as well as the need for data at the local level to help inform decisions regarding funding and policies was a driving force behind the development of the ESMIRC survey.

Capacity for instructional reform and how it is measured is still being understood within the research. While these studies contributed to our understanding of capacity, their perspective of capacity is limited to specific capitals (e.g., human, social, and financial) and dimensions. Additionally, they tend to focus on subjects with policy implications (i.e., literacy and mathematics) as opposed to all subject areas. These limitations prevent the exploration of instructional reform capacity from an ecological lens.

In addition to a lack of surveys examining capacity from an ecological perspective, instructional practices inherent in the current content standards for science and mathematics promote student-centered and activity- or inquiry-based instruction as opposed to exclusively teacher-centered and lecture-driven instruction. Recommendations for instructional practice use as it pertains to student learning has developed substantially with more than 20 years of educational research since subject-specific content standards were introduced in the 1980s. While instructional practices can range on a spectrum from more teacher-centered, lecture-driven to more reform-oriented (i.e., student-centered, activity- or inquiry-based), reform-oriented instructional practices have been shown to be necessary to experience the deep learning required for proficiency in science and mathematics (Bryk et al., 2010; National Council of Teachers of Mathematics [NCTM], 2014; National Research Council [NRC], 2001, 2007, 2008, 2012). Therefore, national organizations representing science and mathematics instruction (i.e., NSTA, NSTM, and NRC) have promoted the inclusion of reform-oriented instructional practices in the classroom.

To address the gap, this study included the development and validation of a survey instrument to measure elementary teachers' instructional reform capacity and instructional practice use pertaining to science and mathematics instruction separately from one another. The survey development and validation process resulted in the ESMIRC survey having 51 instructional reform capacity items and 20 instructional practice items. The ESMIRC survey can provide information to educational leaders regarding the current state of teachers' perceptions of their instructional practices as well as the characteristics of their work context influencing their teaching and learning. Since teacher's perceptions of their instructional practices and characteristics of their work environment influence their uptake of instructional reform, the information from this survey can inform educational leaders' decisions regarding funding and policies for continued instructional reform.

Instructional Reform Capacity Dimensions

One of the primary goals of this study was to determine if the conceptual model of instructional reform capacity presented in chapter 3 was representative of the real world of teachers. In order to validate the framework and dimensions underlying instructional reform capacity, confirmatory factor analyses were performed on the instructional reform capacity items for science and mathematics instruction independently of one another. Models aligned with the conceptual model of five dimensions of instructional reform capacity (*expertise*, *cultural*, *social*, *structural*, and *policy*) were tested. Model fit statistics indicated less than adequate fit of the model with the data suggesting an alternative model may better represent the data. Parallel analysis was performed on the data to determine the number of dimensions underlying the data (i.e., the number of factors to extract). Exploratory factor analyses were performed on science and mathematics independently with the recommended number of factors. Models, suggested by the exploratory factor analyses, underwent confirmatory factor analysis resulting in better model fit to the data than the five dimensions suggested by the conceptual framework (see Table 11, Chapter 4). The validated seven-factor models for science and mathematics had some similar and dissimilar underlying dimensions (see Table 8, Chapter 4).

While all of the elements of capacity (e.g., capitals, cultural norms, climate, and characteristics) supported the underlying seven-dimension structure of instructional reform capacity (see Figure 3, Chapter 2), how they interacted with one another was different for science as compared to mathematics. Elements loading on to pedagogical content knowledge were identical between science. It could be argued that these items, as they were written, are more appropriate for the individual level and less for the organizational level and could be removed (Sleegers et al., 2015); however, when taken together across the respondents, they represent the collective knowledge and skill of the teachers at the organizational level and were kept in the model.

The professional learning and policy dimensions had some overlapping items. Professional learning for both subjects had items representing a commitment to learning and shifting teaching practices as well as value in their perspective and experience in developing a vision for teaching and learning. All of these items have social characteristics which research suggests influences implementation either through formal and informal networks (Coburn, 2001), professional learning communities (Porter et al., 2015), and coaching (Woulfin, 2018). The items differing between science and mathematics described developing expertise for science (i.e., participating in professional development, and incorporating technology for student learning) and social interactions with administration for mathematics suggesting that meetings with administration included conversations that supported the professional learning of teachers specifically for mathematics teaching and learning. The policy dimension of science and mathematics had overlapping items as well including curriculum (i.e., assessment tasks, lessons, activities/labs) being mandated and assessment tasks being aligned with state standards. This aligns with research indicating that districts target professional development, assessment, and curriculum as instruments to align expectations between the standards and the technical environment (Bianchini & Kelly, 2003; Coleman et al., 2012).

Pedagogical content knowledge, professional learning, and policy were the most similar dimensions between science and mathematics.

The leadership dimension for science had double the number of survey items associated with it compared to mathematics (see Table 8, Chapter 4). In mathematics, items underlying the leadership role of administration including communicating the importance of instruction and having high expectations for student learning. However, the leadership dimension for science instruction contained items aligning with distributed leadership including teacher voice in planning of funds, sufficient time for professional development, teacher leadership opportunities, and conversations between teachers and administration focused on teaching and learning. Spillane, Halverson, and Diamond (2004) described distributed leadership as existing "in the interaction of leaders, followers, and their situation in the execution of particular leadership tasks" (p. 10). The additional items present within the leadership dimension for science instructional capacity describe leadership tasks including items aligned to the cultural, social, and structural dimensions of the conceptual framework. The distributed nature of leadership tasks as they relate to science may be due to the limited resources present for the subject and suggests leadership plays a more significant role influencing science teaching and learning with limited resources and a lack of accountability (Spillane et al., 2001).

While social and cultural characteristics were present for both science and mathematics in instructional reform capacity dimensions, they manifested as a single dimension for mathematics and as two separate dimensions for science. The separate dimensions for science predominantly aligned with the conceptual framework proposed in the literature review (see Figure 3, Chapter 2). The social dimension contained items focused on relationships and interactions with colleagues (e.g., working with or discussing student work, teaching experiences, or assessments with other teachers) and engaged both social and political capital. Social relationships among teachers may significantly enhance teacher collaboration and can potentially contribute to instructional practices enacted by teachers as well as student learning (Cosner, 2009; Moolenaar, 2012). The culture dimension included items reflecting the norms, values, and characteristics of the teaching community at the school (e.g., teachers respecting each other's perspectives, support of fellow teachers, safe environment for discussion) (Bryk et al., 2010; Honig & Hatch, 2004; Malen, 2006). Climate is a key element of capacity and engages trust and collaborative culture (Bryk et al., 2010; Gamoran et al., 2003; Mitchell & Sackney, 2011; Seashore Louis & Lee, 2016; Spillane & Thompson, 1997). Even though social and cultural characteristics manifested as different dimensions for science and as a single dimension for mathematics, their presence supports research of these characteristics of instructional reform capacity.

The remaining dimensions for science and mathematics include survey items representing structural characteristics but reveal how capacity manifested differently for science compared to mathematics. Science had a single dimension including items from both the structural and policy dimensions of the framework. The items represented technical capital, organizational structure, as well as district/school policies and initiatives. The structural items included access to materials, classroom space, instructional materials, technology, and schedules supporting science teaching and learning. These items, representing the structural characteristics necessary to support instruction, were present in the dimensions for mathematics as well. Additionally, this dimension of science contained policy items associated with school policies and initiatives, curriculum maps, professional development, as well as school directives aligned with state standards and instructional practices recommended by teaching organizations (e.g., NSTA). In many regards, this dimension for science aligns with instructional guidance infrastructure (IGI) proposed by Hopkins, Spillane, Millerd, and Heaton (2013). In their study of one school system's efforts to redesign its infrastructure for mathematics, they identified infrastructure components (e.g., professional development, organizational routines, and curriculum) work together for teacher leadership to support mathematics instruction.

In contrast to a single structural dimension underlying instructional reform capacity for science, there were two structural dimensions underlying capacity for mathematics. The first was aligned with structural resources related to instruction including accessible and cohesive instructional materials, classroom space or facilities, supportive school schedules, and teacher leadership and decision making related to instruction. The second dimension had structural characteristics centered around professional learning including sustained investment, teacher voice in the use of funds, allocation of time for learning, as well as professional development and initiatives focused on learning. These survey items represented elements from across the dimensions of the proposed conceptual framework suggesting professional learning plays a significant role in elementary mathematics teaching and learning.

The differences evident in the underlying structures of instructional reform capacity between science and mathematics suggest that we cannot look at capacity the same way for all instructional reforms and that capacity has to be looked at through a more holistic lens to capture these differences. Whereas the dimensions underlying instructional reform capacity for science were similar to those of the proposed conceptual framework, the dimensions underlying mathematics were different.

Instructional Practice Use

To better understand the use of instructional practices in elementary science and mathematics, my first research question examined elementary teachers' reported use of instructional practices in their science and mathematics instruction. To measure the use of instructional practices, twenty items representing the spectrum of instructional practices ranging from more teacher-centered to more student-centered asked teachers to report their frequency of use on a 5-point Likert scale ranging from use in *no lessons* to *every lesson*. Teachers reported their use in science and mathematics instruction separately from one another allowing comparison of practices within and between subjects.

Instructional Practices in Science Lessons

In their science lessons, elementary teachers reported using more teacher-centered or lecture-centered, as opposed to reform-oriented (i.e., student-centered or activity- or inquiry-based), instructional practices. Instructional practices included direct instruction to explain or reinforce concepts, teaching vocabulary before the lesson, and using textbooks or other reading materials. Contrastingly, instructional practices used the least aligned with student-centered instruction and included developing a conceptual model based on data or observations, students critiquing each other's reasoning, students displaying and analyzing data, and students collecting data or information. These findings align with those found by Banilower et al. (2018) who reported teachers explained concepts or ideas in all or almost all science lessons in the 2018 NSSME+. Additionally, these findings reinforce the challenge teachers have in taking up and implementing new instructional practices (Coburn, 2004). While these findings align with those found by others regarding the more frequent use of more teacher-centered instructional practices within elementary science lessons, they contrast with instructional practices promoted by science organizations (National Research Council [NRC], 2008, 2012).

Instructional Practices in Mathematics Lessons

In their mathematics instruction, elementary teachers reported using more teacher-centered or lecture-driven instructional practices as opposed to practices considered to be reform-oriented (i.e., student-centered or activity- or inquiry-based). Instructional practices reportedly used the most aligned with teacher-centered instruction and included direct instruction to explain or reinforce concepts, using activity sheets to reinforce skills and content, and teaching vocabulary before the lesson. Contrastingly, instructional practices used the least aligned with student-centered instruction and included development of a conceptual model based on data or observations, students displaying and analyzing data, students collecting data or information, and students critiquing each other's reasoning. These findings align with those found by Banilower et al. (2018) who reported almost three-quarters of teachers explained concepts or ideas in all or almost all mathematics lessons in the 2018 NSSME+. Overall, elementary teachers reported using teacher-centered instructional practices more frequently than reform-oriented instructional practices in their mathematics lessons.

While a majority of the most frequently reported instructional practices used in mathematics lessons were teacher-centered, not all of them were. For example, explanation or justification of methods for solving a problem was used by 85% of teachers in more than half of their lessons. Additionally, making comparisons between multiple representations of solving a problem was used by 64% of teachers in more than half of their lessons. Lastly, students having to explain their reasoning or supply evidence to support a claim or justification was used by 58% of teachers in more than half of their lessons. The presence of some reform-oriented instructional practices in mathematics lessons could provide support for instructional reforms taking place slowly over time.

Comparing Instructional Practice Use

Prior to comparing reported instructional practice use between science and mathematics, it is important to recognize the frequency of instruction as reported by elementary teachers within these two subject areas. Mathematics lessons were much more prevalent to happen during a given week with over 80% of respondents reporting teaching more than 12 lessons in the past month (i.e., more than 3 per week). Contrastingly, about one-quarter of teachers reported teaching science either every other week (n = 42) or once per week (n = 45). Less than six percent of teacher reported teaching science lessons at the same frequency as what most teachers reported for mathematics instruction. Judson (2013) reported significantly higher instructional time for science in states that integrated fourth-grade science assessment into their accountability policies. Analyzing data from the Schools and Staffing Survey from 2007-2008, Blank (2013) reported an average of 5.6 hours of mathematics instruction compared to 2.3 hours of science instruction in Grades 1-4. The reported frequency of instruction for science and mathematics from this study aligns with studies indicating less instructional time for science compared to mathematics (Banilower et al., 2018; Sowder & Harward, 2011).

In addition to these differences between science and mathematics instruction, teachers utilized a greater diversity of instructional practices in their mathematics lessons compared to science lessons. Twelve instructional practices were reported as being used in over half of mathematics lessons by a majority of teachers whereas only seven instructional practices were used that frequently in science lessons by a majority of teachers. Some of the most common instructional practices overlapped including the teacher-centered and discourse practices. Practices reportedly used frequently in mathematics lessons and less so in science lessons included the use of equipment and manipulatives in problem solving or investigations, creation of a drawing or model of a concept or process, making comparisons between multiple representations of solving a problem, and providing explanations of methods for solving a problem. The greater diversity of instructional practices used in mathematics lessons as well as the practices more prevalent aligns with recommendations for development mathematics proficiency in students (National Council of Teachers of Mathematics [NCTM], 2014; National Research Council [NRC], 2001).

Another instructional practice that differed between science and mathematics lesson was students practicing for tests. While 58% of teachers reported using this practice in their mathematics lessons, only 28% of teachers reported using it in their science lessons. While this practice is more teacher-centered, its more prevalent use in math lessons may be aligned with state accountability policies.

When comparing average Likert responses from teachers across instructional practices, there were 16 statistically significant differences. Supporting the findings mentioned above, 14 of the 16 instructional practices were more significantly used in math lessons as opposed to science lessons. This included teacher-centered as well as student-centered instructional practices. Examples of teacher-centered practices that were most statistically different include the use of direct instruction, vocabulary teaching before the lesson, activity sheets used to reinforce skills and content, and students practicing for tests. Examples of student-centered practices used more often in mathematics lessons included development of a conceptual model based on data or observations and creation of a drawing or model of a concept or process. These findings align with those found by Banilower et al. (2018) who reported almost all teachers explained concepts or ideas in all or almost all science and mathematics lessons in the 2018 NSSME+.

While implementation of student-centered (i.e., reform-oriented) instructional practices takes time in the classroom, analysis of the data from the ESMIRC revealed some additional trends that impact student learning in the classroom. Overall, teachers reported more frequent mathematics lessons and more instructional practices used during those lessons. Science lessons, on the other hand, occurred less frequently and utilized fewer instructional practices. These patterns align with state accountability policies which target mathematics as opposed to science.

The Relationship between Capacity and Instructional Practice Use

In order to see how instructional practices are connected with the capacity at the school to undergo instructional reforms, the ESMIRC survey collected data aligned with instructional reform capacity from an ecological organization level. Because the needs and goals of schools can vary depending upon their community (i.e., leadership, teachers, staff, students, families), correlations were done between instructional reform capacity and individual instructional practices as well as composites of instructional practice categories (i.e., teacher-centered and reform-oriented). Composites of the instructional reform capacity dimensions were calculated using averages after being validated by factor analysis (DiStefano et al., 2009). Two categories of instructional practices were created (i.e., teacher-centered and reform-oriented) and composite values were created using averages since the categories were validated in preexisting surveys (Hayes et al., 2016). Values were standardized to remove the impact of different Likert scales. For the purposes of this study, I focus on the relationships of the instructional reform capacity dimensions and the composites of the instructional practice categories while highlighting the individual instructional practices within the categories. While this study does not assess for the predictive relationship between capacity and instructional practice use, the level of association between the dimensions of instructional reform capacity and the types of instructional practice use indicated some significant relationships.

Correlations for Science Instruction

Every dimension of instructional reform capacity for science was significantly correlated with instructional practices described as reform-oriented. Professional learning, leadership, policy, and structure were the most significantly correlated with reform-oriented instruction with professional learning and leadership having the highest correlations. Furthermore, the dimensions of professional learning, leadership, policy, and structure were moderately correlated with reform-oriented instructional practices. This is in alignment with research focusing on professional development, distributed leadership, professional learning community, and cohesive structures to support science teaching and learning (Hayes et al., 2020; Hopkins et al., 2013; Hopkins & Woulfin, 2015; Spillane et al., 2001).

Contrastingly, the correlations between teacher-centered instructional practices and the dimensions of instructional reform capacity were much lower with the exception of policy. The policy dimension was most significantly correlated with teacher-centered instructional practices. The instructional reform capacity items within the policy dimension focused on mandated lessons, and assessment tasks indicating local policies influence the use of both teacher-centered and reform-oriented instructional practices. This could indicate that the required lessons provide support for teachers to incorporate these reform-oriented practices in their science lessons while also reinforcing teacher-centered instructional practices.

Correlations for Mathematics Instruction

Reform-oriented instructional practices were most significantly correlated with professional learning, and structures that support both professional learning and instruction in the classroom. This highlights the possibility that increased accountability of mathematics has created an environment in which schools have funding and access to provide sustained access to professional learning opportunities to teachers aligned with current research-based instructional strategies that are more aligned with student-centered instruction. Reform-oriented instructional practices were minimally correlated to the capacity dimension of leadership. Within mathematics, the leadership dimension consisted of the way in which administration created a culture of consistency, high expectations, communication, and attention to learning. These relationships highlight the importance of administration in creating an environment in which teachers can professionally learn and teach.

Teacher-centered instructional practices were most correlated with the dimensions of professional learning, pedagogical content knowledge, and policy. While professional learning was more correlated with teacher-centered instructional practices, it was more correlated with reform-oriented instructional practices, reinforcing the importance of professional learning on the capacity of teachers to develop as professionals. Pedagogical content knowledge was more correlated with teacher-centered practices as opposed to student-centered practices. This indicates teachers' skills and knowledge in the classroom are still more aligned to teacher-centered practices reinforcing conceptual change to student-centered instructional practices is hard. Lastly, policy was correlated with teacher-centered practices indicating policies at the school level may still represent and reinforce reform-oriented instructional practices.

Comparing Relationships Between Science and Mathematics

The dimension most strongly correlated with instructional practices reportedly used in both science and mathematics lessons was professional learning. This aligns with all of the research on the significance of professional development as a means by which to influence teachers' instructional practices (Abrami et al., 2004; Ceballos, 2012; Council of Chief State School Officers, 2016; Hayes et al., 2020). Hwang (2021) found significant effects of professional development on the use of student-centered instruction.

The cultural dimensions for both science and mathematics (i.e., cultural for science and social-cultural for mathematics) were the only dimensions to have negative correlations with some of the instructional practices. Interestingly, the negative correlations, while not significant, were aligned with more teacher-centered instructional practices. This included direct instruction for both science and mathematics. It also included vocabulary taught before the lesson and students practicing for tests in science as well as the use of computers and technology to learn concepts for mathematics. This may be indicative of a changing culture from more teacher-centered to more student-centered instruction in the classroom.

Limitations

The chosen research design for this study, including survey development and validation as well as sampling procedures, are prone to certain errors and present limitations to the generalizability of the results to the broader population of elementary teachers. The following sections present potential measurement and sampling errors that may pose limitations to the findings of this study.

Collecting data using a survey must be developed and validated to reduce measurement errors. The ESMIRC survey drew on items from previously established surveys in addition to published qualitative research. It underwent modifications through several phases of validity testing including multiple expert panels and a set of cognitive interviews. The online format of the survey was tested during the cognitive interview process to ensure flow, branching, and interpretability. Descriptions of the Likert scale were appropriately aligned with questions and associated with precise descriptions to reduce confusion and misinterpretation. The development was thorough to reduce misinterpretation of survey items and alignment with current research on capacity for instructional reform and instructional practices used by teachers in the population of interest.

While the ESMIRC survey underwent rigorous development and validation procedures, data collected through survey research has errors needing to be addressed. Survey data are self-reported and prone to bias (Blair et al., 2014; Lakin & Wallace, 2015; Nardi, 2018). Additionally, the topics included in the survey, including instructional practices teachers use and characteristics of their teaching and learning environment, may have been considered sensitive to some respondents, particularly considering teachers are evaluated on their classroom instruction. While the survey was not administered by their administrators, the notification did come from their administrators and teachers may not have felt comfortable answering the questions or may have been inclined to answer in a specific manner.

The scale used for instructional practice use provides limitations on the findings from this study. The instructional practice items used a Likert scale aimed at measuring amount of use; however, the unit of analysis was the use within lessons rather than the amount of time within any given lesson. Just because direct instruction and teacher-centered instructional practices are used in more lessons does not mean they are happening for a significant amount of time within those lessons. The purpose of using lessons as the unit of analysis rather than amount of time was two-fold. First, the cognitive demand needed to determine percentages of use is more and would have taken more time thereby disrespecting teachers' time. Second, the survey had to ensure collection of data relating to science instruction. Characteristics of the study's context including state accountability policies and pressures from the pandemic could further reduce the amount of time allocated to science instruction. To guarantee data, teachers were asked to report instructional practice use in each lesson over the last month (i.e., four instructional weeks). While the Likert scale for instructional practice use was well grounded in the context and respectful of teachers' time, it does provide limitations on the findings from the study.

In addition to measurement errors, limitations to generalizability can be present due to the sampling technique used in this study. This study utilized a nonprobability sample (i.e., a sample that is purposively selected) which does not incorporate a randomized process and can be prone to selection bias (Blair et al., 2014). This can create a sample that is not representative of the population of interest. In this particular study, the population of interests was elementary education teachers who taught both science and mathematics to students in grades K-6. While the district was purposively selected, the survey was sent to the administrators of all elementary schools within the district and all schools were contacted to promote involvement in the study. The inclusion of all elementary schools allowed for a representative sample to be obtained from the district; however, the findings cannot be generalized beyond the district sampled.

Given the sample size obtained in this study, generalizability of the results may be limited in their application to elementary teachers within the district sampled. The survey was distributed via email and reminder emails were sent out multiple times during the sampling period. Additionally, I personally contacted schools to develop rapport with them to offset the low response rates online surveys typically have with their audiences (Blair et al., 2014). While the study does have a good sample size, it is a small proportion of the district; therefore, it is most appropriate to state that the data collected can be used to describe the teachers who completed the survey and are in the sample (Nardi, 2018). Additionally, the sample size limits the interpretation of the factor analysis of instructional reform capacity. With the number of dimensions underlying instructional reform capacity, a larger sample size is recommended to minimize errors and maximize the accuracy of population estimates (Osborne, 2014; Osborne et al., 2011).

The limitations of the findings from this study include measurement and sampling errors; however, the research design does shed light onto a process that can be used by schools and districts to create and validate a survey that can be used to data on instructional practice use and instructional reform capacity. These data can then be used to make funding and policy decisions that can influence instructional reforms within the district.

Implications for Future Research

One important implication of this study provides insight into the importance of science education and how it can gain from, but cannot be limited to, the approaches used by researchers looking at other subject areas. The comparison between science and mathematics in this study reveals a drastic difference between how capacity and instruction are occurring in these educational settings. While many studies have looked at subject areas linked to accountability, science and other subjects tend to fall on the outskirts. It is essential that, while funding may be present, research must aim to develop knowledge in all subject areas. There are opportunities for research across subject areas that can further our knowledge of how subjects are taught and engaged within a school. Most importantly, this study sheds light on to the differences that exist across subjects and the importance of research across subject areas.

In addition to studies comparing subject areas, this study has implications for research on instructional reform capacity. Development and validation of the ESMIRC survey enabled the examination of the instructional reform capacity dimensions in schools as well as their relationship to elementary teachers' instructional practice use in science and mathematics. The conceptual framework for this study, depicting five dimensions of instructional reform capacity, was informed by collected data and the analyses supported the interconnected nature of the elements of capacity. This suggests that further analysis validating the interconnected nature of the underlying elements of capacity viewed from an ecological organization perspective is warranted in research aiming to understand capacity at the organizational level. Therefore, research should not be limited to a single dimension or multiple levers if it is to have applicability to schools and districts or on research engaging capacity on the whole. With the diversity of individuals and the variety of external pressures and influences applied to schools differently across subject areas, future studies should measure capacity not as a single entity within a school but as manifesting differently across different subjects. Allowing capacity to manifest in more than one way is necessary to better understand the intertwined nature in the diverse settings of education across subject areas, states, countries, and the globe. While there are still many questions to be answered with the data collected, the findings of this study provide direction for further inquiry.

The results from this study suggest that while there are similar underlying dimensions and capitals of instructional reform capacity for science and mathematics, there are distinct differences. Few researchers have investigated capacity from a holistic, ecological lens (Mitchell & Sackney, 2011) and previous research has not accounted for differences in capacity across subject areas and instead considered it a single entity within a school. While the size of this study does not warrant suggestions to specific modifications to the instructional reform capacity framework proposed by Hayes and Bae, the findings suggest a strong case for further research from an ecological constructivist perspective to determine if, and how, patterns emerge between the elements of instructional reform capacity. This conceptual framework and underlying theory must evolve as more information about the capacity for instructional reform is collected and interconnections between the dimensions are revealed. The findings from this study suggest that development of a theory engaging an ecological lens of instructional reform capacity is necessary. Furthermore, that theory should enable differences to exist across subject areas.

Furthermore, when schools look to build capacity for instructional reform, they must have an understanding of how the elements of capacity interact with one another for each subject area because it has implications for how they make decisions in the school. By breaking down the dimensions into the elements of capacity that interact together within the school setting, stakeholders can have a better understanding of how to leverage different capitals from the perspective of teachers to impact the teaching and learning environment in the school. Furthermore, the relationship between instructional reform capacity and instructional practice use can be helpful to school and district leadership as well as other stakeholders when making decisions about local policies and funding. The strength of correlations between instructional reform dimensions and instructional practices can help identify key elements related to those instructional practices. The underlying dimensions of instructional reform capacity being different for science and mathematics could influence the impact of interventions and professional development opportunities on the development of capacity for instructional reform. In this sample of elementary teachers, similar dimensions of pedagogical content knowledge, professional learning, and policy indicate approaches to leverage these dimensions can be similar for science and mathematics. However, the way leadership and structural supports interact with instructional reform capacity for science as compared to mathematics are distinctly different from one another. While this is probably the result of mathematics being part of the state level accountability requirements for education while science is not, it yields implications for what decision makers and leadership at schools need to do different for science as compared to mathematics. Therefore, to provide students with the opportunity to develop scientific and mathematic proficiency it is essential that interventions and professional development opportunities are offered in alignment with the multifaceted levers to increase capacity. Considering this study looked at a single district to examine the underlying structures of instructional reform capacity, there is still a need for further research in this area.

Lastly, the process by which organizations (i.e., schools and districts) engage with reforms to shift instructional practices and develop student proficiency in science and mathematics is important to understand. Implementation of reform-oriented instructional practices takes time and sustained support on the part of the organization; therefore, sampling of instructional practices and capacity need to take place over time. Development of a survey of this type that can be validated and used by schools and districts can enable them to collect data beyond that required of accountability policies and evaluation requirements.

Conclusion

With the compounded pressures of current content standards implementation and recovery from a pandemic, we need to reimagine public education. Schools, the leadership and teachers, are the foundation of what can support student learning under these pressures. However, the capacity of this collective of individuals to support student learning is dependent upon their capacity as an organization to recognize and adapt to the needs of both the people in the organization as well as the student's needs. With this is mind, this study consisted of two primary components including (1) the development, administration, and validation a survey instrument, ESMIRC, to measure elementary teachers' instructional reform capacity and instructional practice use pertaining to science and mathematics instruction within the context of their school and (2) the analysis of the survey data with descriptive statistics, factor analysis, and correlations to examine instructional practice use as well as the relationship between those practices and the dimensions of instructional reform capacity.

First, this study adds to the existing literature through the analysis of the survey data to determine the dimensional structure underlying instructional reform capacity. Utilizing an ecological organizational perspective of schools, allowing fluidity within an interconnected system, this study theorized a five-dimensional structure (i.e., expertise, cultural, social, structural, and policy) of instructional reform capacity. However, analysis of the data indicated an underlying structure grouping the capitals into seven dimensions. Moreover, some of the dimensions were similar between science and mathematics and some were distinctly different indicating supports and constraints for capacity building manifest in different ways. This cross comparison for capacity is lacking in the literature. These findings highlight the need for more research utilizing a holistic lens to better understand how instructional reform capacity manifests in school settings and for different subjects.

In addition to examining the underlying structure of instructional reform capacity for elementary science as compared to mathematics, this study explored elementary teachers' reported instructional practice use. While it was not surprising to see teacher-centered instructional practices being used the most in both science and mathematics lessons, mathematics lessons engaged more reform-oriented (i.e., student-centered) practices, in addition to teacher-centered practices, which align with recommendations from teaching organizations. Reliance on more teacher-centered instructional practices for science lessons can have negative impacts on student learning. Further research is necessary to determine why limited instructional practices are used in science and identify the best ways to overcome the dependency and extend student engagement through the use of student-centered instructional practices.

Lastly, this study examined the relationships between instructional practice use in science and mathematics lessons and their respective dimensions of instructional reform capacity. By categorizing instructional practices into teacher-centered and reform-oriented (i.e., student-centered) this study examined relationships between capacity more broadly. In alignment with research, professional learning and organizational structures were significantly correlated with the use of reform-oriented instructional practices for both science and mathematics lessons. However, the relationship between leadership and reform-oriented instructional practices was only significant in science lessons. This is contrary to the emphasis placed on leadership in supporting instructional reforms. More research examining capacity from a holistic ecological lens is needed to better understand the relationship between capacity and its outcomes of instructional practices.

Overall, research needs to support schools and districts in building their capacity to overcome the challenges being faced in public education. Whether it be to support teacher professional learning and development, reimagining the teacher workforce, tending to the social-emotional well-being of students, we need to work with schools and districts to establish valid and reliable surveys based in research that can inform the decision-making process. Most importantly, findings from surveys need to be accessible to practitioners and leadership to inform decisions being made to influence instructional reforms. It is essential that schools, teachers, and leaders have the data they need to support the learning of students in their schools.

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APPENDIX A

ESMIRC COGNITIVE INTERVIEW PROTOCOL

Introduction

Before we get started, I want to say THANK YOU! Thank you for all you do. Your role in our children's lives is so important. Now, let me give you some background, and describe what we are going to be doing – and what I'd like you to do. As part of my dissertation, I am developing a questionnaire that will be used for a study about elementary teachers' science and mathematics instructional practices as well as the context of the school in which they work. Draft questionnaires sometimes use words that are not clear or have other problems that make the questionnaire more difficult than it should be. We test questionnaires to try to identify and fix any of these or other problems. One way we do this is by trying out the questions with the help of people like those who will take the survey. That's what I'd like you to help me with today.

I would like to record this cognitive interview. The purpose of this recording is so that I can go back to review anything I may have missed about your feedback/insights while doing the interview. Do I have your permission to record this interview? YES/NO. Remember, you can ask me to stop the recording at any time.

Purpose:
The purpose of this study is to gather information about your instructional practices related to science and mathematics and to better understand how conditions at your school might influence the ways you learn about and teach science and mathematics.

Participants:
In order to participate in this interview, you must be 18 years or older and a current elementary teacher in Arizona teaching science and mathematics to students in any grade between Kindergarten and sixth grade.

What you need to know:
The interview will include your participation in an online survey and the interviewer will discuss your responses with you while you complete the online survey. The interview should take between 25-60 minutes to complete. The interview will take place virtually through a secure Zoom account and will only be recorded with your approval. You can request the recording be stopped at any time. During the interview, the researcher will invite you to talk aloud while you take the survey and ask questions as you progress through the survey to better understand your interpretation of the survey items. Your responses will be identified by number so your responses will be kept confidential. All survey responses will remain confidential, any identifying information will be removed for analysis, and all data will be reported in aggregate. The results of this study may be used in reports, presentations, or publications but your name will not be used, nor will any other identifying information. When the study is over, the survey data will be destroyed. There are no known foreseeable risks associated with taking part in this survey research study. Participation in this study is voluntary and you can stop your participation at any time.

To thank you for participating in this interview and survey completion, participants will be provided with a $30 Amazon gift certificate. Compensation was determined based on participation in similar interviews. The distribution of the incentives will occur upon completion of the interview. In order to receive your gift card, follow the link at the conclusion of the survey to a second survey, separate from the first survey, and please enter your contact information. Your contact information will only be used for the purpose of sending the gift card.

Questions and Concerns: (provide in chat)
If you have any questions concerning the study, please contact me, Kristi Glassmeyer, at Kristi.Glassmeyer@asu.edu or my advisor, Eugene Judson, EdD, at Eugene.Judson@asu.edu. If you have any questions about your rights as a participant, or if you feel you have been placed at risk, you can contact the Chair of Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788. Please reference IRB 11938.

Respondent Instructions

You can open the survey by clicking on the link I have provided in the chat. I'd like you to answer the survey items just as if you had been contacted to do the survey. While you are answering the questions, at any time you can

- Read the survey items aloud
- Share aloud what you are thinking when reading or answering the question
- Let me know any words or phrases that are not clear or that you think some people may not understand
- Let me know any words or phrases that you think might mean different things to different people, or that you would say in a different way.

As we go along, feel free to let me know anything about the questions that you think makes them hard to understand or answer.

Interviewer general instructions

During this interview, I will use two techniques to better understand what you are thinking as you are responding to the questions. One of these techniques is called "think aloud." While you are answering the questions, I will ask you to share what you are thinking. Thinking aloud is not necessarily natural for everyone so I will help with some general questions like

- What were you thinking about when you read the question?
- What makes you think/say that?

- Are there any terms or phrases in the survey item that are confusing?
- Would you tell me in your own words what the statement is saying?
- What are some examples that you would put with the survey item to make it clearer?

Another technique I will use is called probing. Probing is when I ask more specific questions about a question or phrase within a question. The online survey has question probes every 5 questions. I will make sure to pause during this time to gather your feedback. The questions ask you to “Please provide feedback on the questions you just answered. Were any questions confusing? Are there any changes you would suggest?”

Do you have any questions before we begin?

(Provide link to survey in chat)
https://asu.co1.qualtrics.com/jfe/form/SV_aeFlS1DyvDHajae

Please open up the survey using the link provided in the chat. If you are comfortable, can you please share your screen as you proceed through the survey? Feel free to turn your video off if you feel more comfortable. Remember you can ask me to stop recording at any time.

APPENDIX B

ESMIRC SURVEY INSTRUMENT

References and surveys utilized in development of instructional reform capacity and instructional practice survey items on the ESMIRC survey are identified using superscripts at the end of the survey items with references provided at the end of the survey.

Survey Section	#	Item Stem	Item	Answer Choices
1.0 Teacher Role				
		Thank you for your time and consideration of participating in this survey. The purpose of this study is to gather information from K-6 teachers about their school environment and instructional practices related to science and mathematics. I understand teaching right now is different and this survey is not evaluative in any way. Having been a teacher, I respect your expertise and value your time. This survey is looking to better understand how conditions at schools might relate to the ways in which teachers learn about and teach science and mathematics. The online survey should take approximately 15 minutes to complete. All survey responses will be kept confidential. Your responses will be identified by number, any identifying information will be removed for analysis, and all data will be reported in aggregate. The results of this study may be used in reports, presentations, or publications but any identifying information will not be used. When the study is over, the survey data will be destroyed. There are no known foreseeable risks associated with taking part in this survey research study. Participation in this study is voluntary and you can stop your participation at any time. To thank you for participating in this survey, the first 200 participants will be provided with a $15 Amazon gift certificate. Compensation was determined based on similar surveys. The distribution of the incentives will occur four weeks after the initial requests for survey participation. Follow-up requests for participation will be sent every week. In order to receive your gift card, follow the link at the conclusion of the survey to a second survey, separate from the first survey, and please enter your contact information. Your contact information will only be used for the purpose of sending the gift card if you are one of the first 200 participants. If you have any questions concerning the study, please contact me, Kristi Glassmeyer, at Kristi.Glassmeyer@asu.edu or my advisor, Eugene Judson, EdD, at Eugene.Judson@asu.edu. If you have any questions about your rights as a participant, or if you feel you have been placed at risk, you can contact the Chair of Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788. Please reference IRB 11938. I really appreciate your consideration of participating in this survey and for all you do for your students! Thank you. In order to participate in this survey, you must be 18 years or older and a current elementary teacher in Arizona teaching science and/or mathematics to students in any grade between Kindergarten and 6th Grade. By answering the following question with "Yes", you consent to proceed with the survey.		

	1	Do you teach science and/or mathematics to kids in grades K-6 this school year?	Yes; No
		This section of the survey asks for information about your teaching role within your school.	
	2	Which of the following describes the subject area(s) you teach? **[Select one.]**	science; mathematics; both science and mathematics; neither science nor mathematics
	3	Select the grade(s) you teach this school year **[Select all that apply.]**	Kindergarten; 1st Grade; 2nd Grade; 3rd Grade; 4th Grade; 5th Grade; 6th Grade; None of the above
	4	In what format have you been teaching for the last month (four weeks) of instructional time? **[Select one.]**	All in-person classroom teaching; Combination of in-person and virtual learning; All virtual learning (e.g., Remote/Distance/Online learning); Other, please specify:
Teacher Role	5	Which statement best describes your teaching role during this time? [Select one.]	I instruct the same group of students all or most of the day in multiple subjects (general education teacher or self-contained class); I instruct several groups of students, possibly across grade levels, in select subjects (departmentalized teacher of science and/or mathematics); I instruct several classes of students in science or mathematics (science/mathematics specialist); I instruct selected students released from their regular classes in specific skills or to address specific needs (for example: special education, English as a Second Language) (pull-out class); Other (for example: if your teaching role is different for science and mathematics), please specify:
	6	Select the statement(s) that describe the **science instruction** your students have **received in the**	I teach science independently of other subject areas.; I teach science

	last month (four weeks) of instructional time? [Select all that apply.]	integrated with other subject areas (for example: interdisciplinary lesson with social studies).; A science specialist provides most of the science instruction.; Another teacher provides most of the science instruction.; Not applicable (e.g., science is not currently taught); Other, please specify:
7	Select the statement(s) that describe the **mathematics instruction** your students have **received in the last month (four weeks) of instructional time**? [Select all that apply.]	I teach mathematics instruction independently of other subject areas.; I teach mathematics integrated with other subject areas (for example: interdisciplinary lesson with social studies).; A mathematics specialist provides most of the mathematics instruction.; Another teacher provides most of the mathematics instruction.; Not applicable (e.g., mathematics is not currently taught); Other, please specify:
8	What is the name of your district (This information will only be used to combine data. It will not in any way be connected to your responses which remain confidential.)?	Mesa; Other, please specify
9	What is the name of your school (This information will only be used to combine data. It will not in any way be connected to your responses which remain confidential.)?	Text
2.0 Instructional Reform Capacity		

The following items will give you an opportunity to share your experiences as an educator in your current work environment. If you are on a mobile device or tablet, you may want to hold it horizontally. Remember this is not evaluative and all responses are confidential. Please answer openly and truthfully.

Expertise	1	Please indicate the degree to which you agree or disagree with each statement below:	I regularly participate in professional development to learn new information and skills for __________ teaching. [11,17,19]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	2		I am committed to learning new knowledge and skills for __________ teaching and learning. [9,17]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	3		My perspective and experience of __________ teaching is valuable in developing a vision for __________ teaching and learning at my school. [11]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	4		I am committed to shifting my teaching practices to support student learning in __________.[17]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	5		I work with colleagues at my school to develop shared meanings of __________ teaching and student learning. [11]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	6		I use technology effectively to support students in building their __________ knowledge.	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	7		I am knowledgeable about the __________ content I am expected to teach. [4,14]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	8		I plan __________ instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity. [1]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	9		I have sufficient __________ expertise to respond to the challenges faced by students from diverse backgrounds and language or ability proficiencies. [4,8,14]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	10		I use instructional strategies that enable students to build/construct their own knowledge in __________. [19]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree

The following items will give you an opportunity to share your experiences as an educator in your current work environment. Please answer openly and truthfully.

Culture	1	Please indicate the degree to which you agree or disagree with each statement below:	I have a voice in what happens in my classroom for ___________ teaching and learning (for example: curriculum and instruction). [8,18]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	2		Teachers demonstrate a collective responsibility to improve student learning in ___________ (for example: meet and discuss). [2,4,12,15,19]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	3		It's okay to discuss feelings, worries, and frustrations regarding __________ teaching and learning with other teachers in this school. [6,11,18]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	4		Teachers at this school respect my perspective of ___________ teaching and learning even if we have differing views. [8,14]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	5		I am free to participate in professional communities or learning communities focused on __________ teaching and learning as I see fit. [11]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	6		I am supported by colleagues to try out new ideas in ___________ teaching. [18,19]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	7	Please indicate the degree to which you agree or disagree with each statement below:	I have a voice in planning how funds should be used for student's ___________ learning (for example: budgets, supply ordering, grants). [8,18]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	8		There is a shared vision and a common purpose among teachers focused on ___________ student learning within and across grade levels. [5,10]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	9		There is consistency between what my administrators say and what they end up doing for ___________ teaching and learning. [14]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	10		Professional development focused on __________ teaching and learning is valued in this school. [4,11]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	11		My administrators are genuinely attentive to my concerns around curriculum and pedagogy for ___________. [4,8]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree

	12		My administrators clearly communicate the importance of __________ instruction. [8]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	13		My administrators demonstrate high expectations of __________ learning for all students no matter their background, language or ability proficiencies. [14,18]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
		The following items will give you an opportunity to share your experiences as an educator in your current work environment. Please answer openly and truthfully.		
Social	1	Please indicate the degree to which you agree or disagree with each statement below:	I regularly work with other teachers at my school to develop or plan __________ instruction (for example: goals, objectives, lessons, activities, labs). [8,14]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	2		I regularly share and discuss __________ assessment tasks with other teachers at my school (for example: formative and summative assessments).[8]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	3		I regularly discuss my __________ teaching experiences with other teachers at my school (for example: instructional practices, strategies, successes, challenges).[4,16]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	4		I regularly engage with other teachers at my school when analyzing students' __________ work. [8]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	5		My relationships with other teachers at my school are supportive of my _________ instruction. [11]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	6		Discussions with a colleague at my school has made me rethink or adjust my __________ teaching.	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	7		Conversations with my administrator(s) has made me rethink or adjust my __________ teaching.	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree

	8		My administrators meet with me to discuss my __________ teaching and listen to my needs regarding __________ instruction and student learning. [8]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	9		My administrators involve teachers in discussions when developing solutions to meet the needs of __________ education. [8]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
		The following items will give you an opportunity to share your experiences as an educator in your current work environment. Please answer openly and truthfully.		
	1	Please indicate the degree to which you agree or disagree with each statement below:	There is sufficient technology to provide students with opportunities for __________ learning (for example: computers, Wi-Fi, Google Classroom, SeeSaw). [7]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	2		There is sustained investment focused on _________ teaching and learning for teachers (for example: professional development, training, support, materials). [4,19]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	3		Sufficient time is allocated for teachers to develop professionally in _________ teaching and learning (for example: participate in professional discourse, observe one another).	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
Structure	4		Programs (for example: professional development, trainings) provided at my school focus on _________ instructional practices. [11]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	5		Teachers have opportunities for leadership and decision making that impact _________ teaching and learning at the school-level. [11]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	6		Materials for __________ instructional activities are accessible (for example: books, supplies).[4]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	7		There is enough classroom space or facilities (for example: lab space) to support __________ instruction. [8]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	8		Learning expectations within and across grade levels for __________ are cohesive, preventing learning gaps. [4]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree

	9		___________ instructional materials used at this school are cohesive. [4]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	10		The school schedule provides sufficient time to support ___________ instruction and learning for all students. [4,14]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
		The following items will give you an opportunity to share your experiences as an educator in your current work environment. Please answer openly and truthfully.		
	1	Please indicate the degree to which you agree or disagree with each statement below:	School initiatives support experimentation with ___________ instructional practices. [11]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	2		School directives and initiatives are aligned with current state ___________ standards.	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	3		School policies and initiatives are aligned with instructional practices recommended by a ___________ professional teaching organization (for example: NCTM, NSTA) [4]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	4		Curriculum maps/Pacing guides facilitate ___________ instructional practices that promote student learning in ___________.	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
Policy	5		Assessment tasks (for example: tests, quizzes, projects, etc.) used at this school are aligned to ___________ state standards. [4]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	6		Programs provided at my school (for example: professional development, trainings) support ___________ teaching and student learning. [18]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	7		Major initiatives provide support and resources for ___________ teaching and student learning. [8,18]	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	8		___________ assessment tasks (for example: tests, quizzes, projects, etc.) are mandated (required).	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree
	9		___________ lessons and activities/labs are mandated (required).	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree

3.0 Instruction				
		This section of the survey asks for information about your science and mathematics teaching in the past month. Please answer the questions in regards to your instruction in the past month meaning the last four instructional weeks. If you are on a mobile device or tablet, you may want to hold it horizontally. Remember this is not evaluative and all responses are confidential. Please answer openly and truthfully.		
Instruction Frequency	1		**In the last month (four instructional weeks)**, how many lessons (45 min-1 hour) of **science instruction** were provided to your students (including lessons integrating science with other subjects)?	0 lessons; 1-2 lessons (around 1 every other week); 3-4 lessons (around 1 per week); 5-8 lessons (around 2 per week); 9-12 lessons (around 3 per week); More than 12 lessons
	2		**In the last month (four instructional weeks)**, how many lessons (45 min-1 hour) of **mathematics** instruction were provided to your students (including lessons where you integrate mathematics with other subjects)?	0 lessons; 1-2 lessons (around 1 every other week); 3-4 lessons (around 1 per week); 5-8 lessons (around 2 per week); 9-12 lessons (around 3 per week); More than 12 lessons
		This section of the survey asks you about your science and mathematics lessons.		
Instructional Practices	1	How often did the following take place during your science and/or mathematics lessons **in the last month (four instructional weeks)?**	Direct instruction to explain or reinforce ___________ concepts to the whole class [1,8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
	2		Group discussions where students make sense of ___________ concepts [1,8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
	3		Open-ended questions used to stimulate whole class discussion (most students participate) [8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
	4		Concepts were used to explain natural events or real-world phenomena [8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
	5		Vocabulary was taught before the lesson [8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
	6		Activity sheets were used to reinforce skills and content [8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson

7		Students practiced for tests [1]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
8		Computers, calculators, or other technology were used to learn concepts [3,18]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
9		Equipment, measuring tools, or manipulatives were used in problem-solving/investigations [13,18]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
10		Textbooks, fiction or nonfiction books, or other materials (for example: reading passages/sections, newsletters) were read in class, either aloud or silently [1,3,8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
1	How often did the following take place during your science and/or mathematics lessons **in the last month (four instructional weeks)?**	A conceptual model was developed based on data or observations (model is not provided by textbook or teacher) (for example: graphs and data displays) [8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
2		A drawing or model (3-D, conceptual) of a concept or process was created (for example: a drawing of the solar system, model of a cell, using manipulatives to model addition, area or array model for multiplication) [3,8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
3		An investigation or experiment was performed (for example: hands-on, virtual, simulations) [1]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
4		Multiple representations of solving a problem were compared (for example: numbers, tables, graphs, pictures)	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
5		Methods for solving a problem were explained or justified [8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
6		Students collected data or information [3,8]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
7		Students displayed and analyzed data [1,3,8,18]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson

8		Students had to explain their reasoning and/or supply evidence to support a claim or explanation [1,8,18]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
9		Students respectfully critiqued each other's reasoning [7]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
10		Students reflected on their work in class or for homework (for example: in their journals) [1,3]	No lessons; A few lessons; About half of the lessons; Most lessons; Every lesson
4.0 Teacher Background & Demographics			
	This last section has a few questions about your experiences with professional development as well as some questions about your background. Remember all responses are confidential. Please answer openly and truthfully.		
1		What is the total amount of time you have spent on professional development **focused on science or science teaching in the last 2 years**?	0 hours; 1-5 hours; 6-10 hours; 11-15 hours; 16-20 hours; 21-25 hours; 26-30 hours; more than 30 hours
2	Please indicate the degree to which you agree or disagree with the following statements regarding your participation in professional development **over the last two years:** The professional development was highly aligned with:	My own science teaching goals; my district's policies for science teaching and learning practices; my school's policies for science teaching and learning practices; Arizona Science Standards; three-dimensional science teaching as promoted by the National Science Teachers Association (NSTA)	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree; Not Applicable
3		What is the total amount of time you have spent on professional development **focused on mathematics or mathematics teaching in the last 2 years**?	0 hours; 1-5 hours; 6-10 hours; 11-15 hours; 16-20 hours; 21-25 hours; 26-30 hours; more than 30 hours
4	Please indicate the degree to which you agree or disagree with the following statements regarding your participation in	My own teaching goals; my district's policies for mathematics teaching and learning practices; my school's policies for mathematics teaching and learning practices; Arizona Math Standards; instructional practices promoted by the National Council of Teachers of Mathematics (NCTM)	Strongly Disagree; Disagree; Slightly Disagree; Slightly Agree; Agree; Strongly Agree; Not Applicable

		professional development **over the last two years:** The professional development was highly aligned with:		
		These last questions will give you an opportunity to tell us a little more about yourself. Your information will remain confidential.		
	5		How many years have you been teaching (include the current year)?	Text
	6	Select all of the fields in which you have earned a bachelor's and/or graduate degree? (With regard to bachelor's degrees, count only areas in which you majored.) **[Select all that apply.]**	Education, Computer Science, Engineering, Mathematics, Natural Science (e.g., biology, physics, etc.), Other, please specify:	Yes; No
Demographics				
	7		Select all of the education degree(s) you have earned. (With regard to bachelor's degrees, count only areas in which you majored.) **[Select all that apply.]**	Elementary Education, Secondary Education, Mathematics Education, Science Education, Other Education, please specify:
	8		Please identify your sex:	Male; Female; Other; Prefer not to say
	9		Please select the racial group(s) with which you identify: **[Select all that apply.]**	American Indian or Alaska Native; Asian; Black or African American; Hispanic or Latino/a; Native Hawaiian or other Pacific Islander; White or Caucasian

Thank you so much for your time in participating in this survey and all that you do for your students! To thank you for taking the time to participate in this survey, I would like to provide the first 200 respondents with a $15 Amazon gift card. Compensation was determined based on those given by similar surveys. The distribution of the incentives will occur four weeks after the initial requests for survey participation. In order to be considered to receive a gift card, respond "yes" to the question below so that you can be directed to a second survey separate from this survey. The second survey will ask for your contact information which will only be used for the purpose of sending the gift card.

Would you like to be directed to another survey where you can enter your contact information to receive a $15 Amazon gift card if you are one of the first 200 respondents? Your responses remain confidential.

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APPENDIX C

INSTITUTIONAL REVIEW BOARD DOCUMENTS

Initial Study Exemption

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Eugene Judson
Division of Educational Leadership and Innovation - Tempe
480/727-5216
Eugene.Judson@asu.edu

Dear Eugene Judson:

On 3/1/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Organizational Instructional Reform Capacity Influencing Elementary Teachers' Science & Mathematics Instructional Practices
Investigator:	Eugene Judson
IRB ID:	STUDY00011938
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Consent within pilot & survey, Category: Consent Form; • Pilot, Main, & Compensation Surveys, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Recruitment Email for Pilot Interview, Category: Recruitment Materials; • Recruitment Email for Survey, Category: Recruitment Materials; • Study Protocol, Category: IRB Protocol;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 3/1/2021.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

Sincerely,

IRB Administrator

cc: Kristi Glassmeyer
Kristi Glassmeyer
Eugene Judson

Final Modification Approval

APPROVAL: MODIFICATION

Eugene Judson
Division of Educational Leadership and Innovation - Tempe
480/727-5216
Eugene.Judson@asu.edu

Dear Eugene Judson:

On 9/29/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Modification / Update
Title:	Organizational Instructional Reform Capacity Influencing Elementary Teachers' Science & Mathematics Instructional Practices
Investigator:	Eugene Judson
IRB ID:	STUDY00011938
Funding:	Name: American Educational Research Association, Grant Office ID: FP00029643
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Consent within pilot & survey, Category: Consent Form; • Pilot, Main, & Compensation Surveys, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Recruitment Email for Survey, Category: Recruitment Materials; • Study Protocol, Category: IRB Protocol;

The IRB approved the modification.

When consent is appropriate, you must use final, watermarked versions available under the “Documents” tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

REMINDER - All in-person interactions with human subjects require the completion of the ASU Daily Health Check by the ASU members prior to the interaction and the use of face coverings by researchers, research teams and research participants during the interaction. These requirements will minimize risk, protect health and support a safe research environment. These requirements apply both on- and off-campus.

The above change is effective as of July 29th 2021 until further notice and replaces all previously published guidance. Thank you for your continued commitment to ensuring a healthy and productive ASU community.

Sincerely,

IRB Administrator

cc: Kristi Glassmeyer
Kristi Glassmeyer
Eugene Judson

APPENDIX D

SURVEY RECRUITMENT EMAILS

Initial Solicitation Email

Subject: MPS Research Committee Approved: Survey opportunity for K-6 teachers with $15 incentive

Dear Dr./Principal XXX,

I am reaching out to ask you to forward the following message about my study on to your K-6 teachers. My request to conduct research through this study was approved by the Mesa Public Schools Research Priority Board and Dr. Carlisle is my point of contact. The study involves a survey asking K-6 teachers about their teaching and learning experiences. The first 200 participants will receive a $15 Amazon gift card in appreciation of their time. I am trying to offer this opportunity through an online survey format so as to minimize disruption and hopefully provide them with a little token of gratitude. I really appreciate your consideration of passing along this invitation to participate to your K-6 teachers.

If you would prefer for me to do a short presentation (in person or via online platform) about the survey or study, I am more than happy do so and would love to coordinate that with you. If you have any questions about the study, you can contact me at Kristi.Glassmeyer@asu.edu. If you have questions about the approval by the Mesa Research Committee, Mr. Carlisle has conveyed that you can reach out to him directly. Thank you so much for your time and all you do to support the staff, students, and teachers at your school.

Sincerely,
Kristi Glassmeyer

PhD Candidate
Mary Lou Fulton Teachers College, ASU

Email Message to be sent to K-6 teachers

Subject: Survey for K-6 teachers with $15 incentive opportunity!

Hello Elementary Teachers,

My name is Kristi Glassmeyer and I am a graduate student in Mary Lou Fulton Teachers College at Arizona State University. I am reaching out to offer you **an opportunity to get a $15 gift card for completing a one-time survey**. As part of my dissertation, I am conducting a study of elementary teachers' teaching and learning experiences. Having been a teacher myself, this survey draws upon your expertise while respecting your time.

This survey is not evaluative in any way and your responses will be kept confidential. All of the information about this survey and your participation is provided below.

Purpose:

The purpose of this study is to gather information from K-6 teachers about their school environment and instructional practices related to science and mathematics. This study is looking to better understand how conditions at schools might relate to the ways in which teachers learn about and teach science and mathematics.

Participants:

In order to participate in this survey, you must be 18 years or older and a current elementary teacher in Arizona teaching science and/or mathematics to students in any grade between Kindergarten and 6th Grade.

What you need to know:

The online survey should take approximately 15 minutes to complete. All survey responses will be kept confidential. All survey responses will be identified by number, any identifying information will be removed for analysis, and all data will be reported in aggregate. The results of this study may be used in reports, presentations, or publications but any identifying information will not be used. When the study is over, the survey data will be destroyed. There are no known foreseeable risks associated with taking part in this survey research study. Participation in this study is voluntary and you can stop your participation at any time.
To thank you for participating in this survey, the first 200 participants will be provided with a $15 Amazon gift certificate. Compensation was determined based on similar surveys. The distribution of the incentives will occur four weeks after the initial requests for survey participation. Follow-up requests for participation will be sent every week. In order to receive your gift card, follow the link at the conclusion of the survey to a second survey, separate from the first survey, and please enter your contact information. Your contact information will only be used for the purpose of sending the gift card if you are one of the first 200 participants.

Questions and Concerns:

If you have any questions concerning the study, please contact me, Kristi Glassmeyer, at Kristi.Glassmeyer@asu.edu or my advisor, Eugene Judson, EdD, at Eugene.Judson@asu.edu. If you have any questions about your rights as a participant, or if you feel you have been placed at risk, you can contact the Chair of Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788. Please reference IRB 11938.

Thank you for your time and consideration of participating in this survey. Most importantly, THANK YOU for all you do for your students!

SURVEY LINK:

https://asu.co1.qualtrics.com/jfe/form/SV_7Px3rYQYdK99Xue

Sincerely,
Kristi Glassmeyer

PhD Candidate
Mary Lou Fulton Teachers College, ASU

First Reminder Email

Subject: Touching Base: $15 incentive still available for K-6 teacher participation in MPS Research approved one-time survey

Dear Dr./Principal XXX,

Thank you so much for sending out my survey opportunity to your teachers. I am reaching out to ask you to send a reminder to your K-6 teachers about my study. I have included the email below. Almost half of the 200 incentives ($15 Amazon gift card) for teachers are unclaimed and I would love to provide them as a token of appreciation. The study involves a survey asking K-6 teachers about their teaching and learning experiences. I really appreciate your consideration of passing along this invitation to participate to your K-6 teachers.

If you are interested in me doing a short presentation (in person or via online platform) about the survey or study, I am more than happy do so and would love to coordinate that with you. If you have any questions about the study or its approval, you can contact either myself, Kristi.Glassmeyer@asu.edu, or Dr. Robert Carlisle. Thank you so much for your time and all you do to support the staff, students, and teachers at your school.

Sincerely,
Kristi Glassmeyer

PhD Candidate
Mary Lou Fulton Teachers College, ASU

Email Message to be sent to K-6 teachers

Subject: Reminder: $15 incentives still available for participation in one-time survey for K-6 teachers!

Hello Elementary Teachers,

My name is Kristi Glassmeyer and I am a graduate student in Mary Lou Fulton Teachers College at Arizona State University. I am reaching out to offer you **an opportunity to get a $15 gift card for completing a one-time survey**. As part of my dissertation, I am conducting a study of elementary teachers' teaching and learning experiences. Having been a teacher myself, this survey draws upon your expertise while respecting your time. This survey is not evaluative in any way and your responses will be kept confidential. All of the information about this survey and your participation is provided below.

Purpose:

The purpose of this study is to gather information from K-6 teachers about their school environment and instructional practices related to science and mathematics. This study is looking to better understand how conditions at schools might relate to the ways in which teachers learn about and teach science and mathematics.

Participants:

In order to participate in this survey, you must be 18 years or older and a current elementary teacher in Arizona teaching science and/or mathematics to students in any grade between Kindergarten and 6th Grade.

What you need to know:

The online survey should take approximately 15 minutes to complete. All survey responses will be kept confidential. All survey responses will be identified by number, any identifying information will be removed for analysis, and all data will be reported in aggregate. The results of this study may be used in reports, presentations, or publications but any identifying information will not be used. When the study is over, the survey data will be destroyed. There are no known foreseeable risks associated with taking part in this survey research study. Participation in this study is voluntary and you can stop your participation at any time.
To thank you for participating in this survey, the first 200 participants will be provided with a $15 Amazon gift certificate. Compensation was determined based on similar surveys. The distribution of the incentives will occur four weeks after the initial requests for survey participation. Follow-up requests for participation will be sent every week. In order to receive your gift card, follow the link at the conclusion of the survey to a second survey, separate from the first survey, and please enter your contact information. Your contact information will only be used for the purpose of sending the gift card if you are one of the first 200 participants.

Questions and Concerns:

If you have any questions concerning the study, please contact me, Kristi Glassmeyer, at Kristi.Glassmeyer@asu.edu or my advisor, Eugene Judson, EdD, at Eugene.Judson@asu.edu. If you have any questions about your rights as a participant, or if you feel you have been placed at risk, you can contact the Chair of Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788. Please reference IRB 11938.

Thank you for your time and consideration of participating in this survey. Most importantly, THANK YOU for all you do for your students!

SURVEY LINK:
https://asu.co1.qualtrics.com/jfe/form/SV_7Px3rYQYdK99Xue

Sincerely,
Kristi Glassmeyer

PhD Candidate
Mary Lou Fulton Teachers College, ASU

Final Reminder Email

Subject: Final Reminder: Some $15 incentives still available for K-6 teacher participation in MPS Research approved one-time survey

Dear Dr./Principal XXX,

Thank you so much for sending out my survey opportunity to your teachers. I am reaching out to ask you to send a final reminder about my study to your K-6 teachers. I know you are busy so I have included the email below. Less than 50 of the incentives ($15 Amazon gift card) for teachers remain and I would love to provide them as a token of appreciation. The study involves a survey asking K-6 teachers about their teaching and learning experiences. I sincerely appreciate your consideration of passing along this invitation to participate to your K-6 teachers. If you have any questions about the study or its approval, you can contact either myself, Kristi.Glassmeyer@asu.edu, or Dr. Robert Carlisle at the district office. Thank you so much for your time and all you do to support the staff, students, and teachers at your school.

Sincerely,
Kristi Glassmeyer

PhD Candidate
Mary Lou Fulton Teachers College, ASU

Email Message to be sent to K-6 teachers

Subject: Final Reminder: $15 incentives still available for participation in one-time survey for K-6 teachers!

Hello Elementary Teachers,

My name is Kristi Glassmeyer and I am a graduate student in Mary Lou Fulton Teachers College at Arizona State University. I am reaching out to offer you **an opportunity to get a $15 gift card for completing a one-time survey**. As part of my dissertation, I am conducting a study of elementary teachers' teaching and learning experiences. Having been a teacher myself, this survey draws upon your expertise while respecting your time. This survey is not evaluative in any way and your responses will be kept confidential. All of the information about this survey and your participation is provided below.

Purpose:

The purpose of this study is to gather information from K-6 teachers about their school environment and instructional practices related to science and mathematics. This study is looking to better understand how conditions at schools might relate to the ways in which teachers learn about and teach science and mathematics.

Participants:

In order to participate in this survey, you must be 18 years or older and a current elementary teacher in Arizona teaching science and/or mathematics to students in any grade between Kindergarten and 6th Grade.

What you need to know:

The online survey should take approximately 15 minutes to complete. All survey responses will be kept confidential. All survey responses will be identified by number, any identifying information will be removed for analysis, and all data will be reported in aggregate. The results of this study may be used in reports, presentations, or publications but any identifying information will not be used. When the study is over, the survey data will be destroyed. There are no known foreseeable risks associated with taking part in this survey research study. Participation in this study is voluntary and you can stop your participation at any time.

To thank you for participating in this survey, the first 200 participants will be provided with a $15 Amazon gift certificate. Compensation was determined based on similar surveys. The distribution of the incentives will occur four weeks after the initial requests for survey participation. Follow-up requests for participation will be sent every week. In order to receive your gift card, follow the link at the conclusion of the survey to a second survey, separate from the first survey, and please enter your contact information. Your contact information will only be used for the purpose of sending the gift card if you are one of the first 200 participants.

Questions and Concerns:

If you have any questions concerning the study, please contact me, Kristi Glassmeyer, at Kristi.Glassmeyer@asu.edu or my advisor, Eugene Judson, EdD, at Eugene.Judson@asu.edu. If you have any questions about your rights as a participant, or if you feel you have been placed at risk, you can contact the Chair of Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788. Please reference IRB 11938.

Thank you for your time and consideration of participating in this survey. Most importantly, THANK YOU for all you do for your students!

SURVEY LINK:
https://asu.co1.qualtrics.com/jfe/form/SV_7Px3rYQYdK99Xue

Sincerely,
Kristi Glassmeyer

PhD Candidate
Mary Lou Fulton Teachers College, ASU