AN EXAMINATION OF ELEMENTARY TEACHERS' MATHEMATICAL QUALITY OF INSTRUCTION AND USE OF INSTRUCTIONAL MATERIALS

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Abstract

Providing high quality mathematics instruction is complex and challenging and necessitates a range of knowledge, dispositions, and skills. Mathematics teachers need mathematical knowledge for teaching, productive beliefs and attitudes towards mathematics, and skills necessary for implementing effective classroom practices. Researchers have found that this combination is particularly illusive for elementary teachers, who train as generalists. As a result, decades of research on teaching suggests elementary mathematics instruction would benefit from additional supports. In particular, a number of studies have suggested that standards-aligned curricular materials and systematic, subject-specific observation protocols can provide support to elementary teachers to improve the mathematical quality of instruction. At a rural, Title 1 elementary school in Pennsylvania, administrators used anecdotal observations and student data to identify an organization challenge: K-2 teachers are inconsistently providing high quality mathematics instruction and/or using standards-aligned curricular materials. This mixed-method study sought to address this problem of practice by evaluating the instructional materials teachers used to plan for and enact mathematics instruction, coupled with classroom observations focused on the mathematical quality of instruction. Data collection included a teacher survey, three thirty-minute recorded classroom observations, and one semi-structured interview. Instruments included the 2019 American Instructional Resources Survey, the 2014 Mathematical Quality of Instruction observation protocol, and semi-structured interview protocols. Findings were used to inform recommendations for future professional learning opportunities and curricular initiatives in the district.

Keywords: mathematics, instructional quality, instructional materials

DEDICATION

To my students, who have inspired me and shaped who I am as an educator.

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List of Abbreviations

AIRS	2019 American Instructional Resources Survey
enVisionMath	*enVisionMath Common Core*, Realize Edition © 2105
Guiding Kinders	Guiding Kinders: Kindergarten Math Curriculum for the Whole Year – Lesson Plans, Worksheets, etc. (Jump & Willis, n.d.)
IRB-SBS	Institutional Review Board for Social and Behavioral Sciences
MKT	Mathematical Knowledge for Teaching
MQI	2014 Mathematical Quality of Instruction Observation Protocol
NCTM	National Council of Teachers of Mathematics
PLO	Professional Learning Opportunities

Chapter 1: Introduction

Teaching is a highly complex process that requires a range of knowledge, dispositions, and skills (Biech, 2017). This is important across all subject areas, but the complexity has presented particular challenges in elementary mathematics instruction. Researchers have found that elementary teachers need additional support to provide high-quality mathematics instruction due to a variety of variables like subject-specific mathematics knowledge (Hill & Charalambous, 2012a), beliefs and attitudes towards mathematics (Ernest, 1989), and knowledge of effective pedagogical approaches (Grossman et al., 2018). Consequently, researchers have spent decades trying to understand how to prepare elementary teachers, who are largely generalists with limited mathematics coursework, to improve mathematics instruction. In this chapter, I provide background information about the macro problem of practice. Following this, I introduce the micro problem of practice and provide contextual information. Last, I share the conceptual framework which provides a lens to examining the problem of practice along with a list of operationalized definitions.

Macro Problem of Practice

In the United States, providing high-quality mathematics instruction continues to be a challenge for teachers (National Research Council, 2001, [NRC]). Over the last several decades, there have been many efforts to understand how to improve instructional quality in the area of mathematics. In 1989, the National Council of Teachers of Mathematics (NCTM) introduced the *Curriculum and Evaluation Standards*. This prompted researchers to explore characteristics of high-quality mathematics instruction and define features of standards-aligned curricular materials to support the reform of mathematics instruction (Trafton et al., 2001). Researchers agree that the changes teachers need to adopt to meet these standards are not "quickly attained and will require ongoing support over an extended period of time" (p. 263). In particular, teachers need opportunities to increase their own mathematical knowledge of teaching, reflect on their beliefs about mathematics instruction, and engage in professional development to understand and utilize curricular materials. To improve the quality of mathematics instruction, teachers need strategic supports to help develop the knowledge, dispositions, and skills needed to be effective.

There are various factors that influence the quality of mathematics instruction in the classroom. Specifically, Hiebert and Grouws (2007) argue that students' opportunities to learn are the "classroom interactions among teachers and students around content directed toward facilitating students' achievement of learning goals" (p. 377). Furthermore, the instructional materials teachers used to plan and enact mathematics instruction impact the quality of these interactions (Cohen et al., 2003; Hill & Charalambous, 2012b; Stein & Smith, 1998). Instructional materials (e.g., curricular materials, supplemental worksheets, etc.) can inform the rigor of mathematical tasks, how teachers address student errors (Hill & Charalambous, 2012b), and teachers' knowledge of mathematics teaching (Remillard, 2005). Therefore, it is important to understand both the instruction that is happening in classrooms and the instructional materials teachers use to plan for and enact mathematics instruction.

Classroom observation instruments provide a systematic way to evaluate instructional quality across multiple lessons and multiple classrooms (Grossman et al., 2018; Pianta & Hamre, 2009). Traditionally, those conducting classroom evaluations use generic observation tools to observe for pedagogical practices and do not measure subject-specific features of instruction. Some have argued that if we want to improve more subject-specific aspects of teaching, we also need subject-specific systematic observation instruments that provide teachers more targeted feedback (Cohen & Goldhaber, 2016; Hill & Grossman, 2013).

However, observation instruments alone cannot measure all variables of instructional quality. Cohen and colleagues (2020) suggest using multiple measures to gain a more complete understanding of instructional quality. One factor not easily observed is the use of instructional materials to plan for and enact instruction. This is an important factor to consider because instructional materials can influence the quality of instruction based on their alignment to and support of rigorous academic standards (Knake et al., 2021; Opfer et al., 2018). That is, what the students are doing in terms of mathematical tasks is as important as the methods teachers use. Consequently, it would be useful to understand the teaching practices enacted in classrooms alongside the instructional materials teachers utilize to plan for observed instruction.

Micro Problem of Practice

Hillside Elementary School[1] is a rural Title I school. After reviewing the 2018-2021 test results from the Pennsylvania System of School Assessment (PSSA), the data team (i.e., director of curriculum and instruction, building principal, and grade level representatives) identified that students in third and fourth grade are not performing at the same level in mathematics as they are in reading. Because of this, leadership (i.e., superintendent, direction of curriculum and instruction, and building principal) included "improve mathematics achievement" in the strategic improvement plan for the last four years. Also, in the 2023-2024 school year, the director of curriculum and instruction intends to purchase a new mathematics curriculum. Considering this, it is necessary to investigate the mathematics instructional practices of teachers in conjunction

[1] All names are pseudonyms.

with their use of instructional materials (e.g., *enVisionMath Common Core, Realize Edition © 2105 [enVisionMath]*).

District-level data provides evidence of weaker mathematics achievement in grades three and four, but there is no systematically collected information about the quality of instruction or student achievement in primary grades (i.e., K-2). Teachers introduce foundational mathematical skills in primary grades. If students do not master these skills, it might negatively influence their mathematics achievement in later grades. For example, if a child does not master their basic addition and subtraction facts with a sum or difference less than or equal to 20, it will be more challenging for them to master multi-digit addition and subtraction in third and fourth grade. Additionally, achievement in primary grades is predictive of academic achievement in future grades (Minor et al., 2015; Watts et al., 2014). Therefore, it is important that the investigation of mathematical quality of instruction begins at the source: kindergarten, first grade, and second grade.

Along with this context-specific evidence, I have personal experience with the struggle to provide high-quality mathematics instruction in three different school settings and three different grade levels. As a novice teacher, I worked in a context that did not provide a standards-aligned curriculum to support instructional decisions. Instead, I developed my own scope and sequence aligned to state standards and I was required to develop my own instructional materials (e.g., worksheets, center activities, lesson plans, etc.). I taught students in the ways that I had learned mathematics, with a focus on procedural knowledge. In the second school site, they provided me with a standards-aligned curriculum (i.e., *enVisionMath*) and I worked on the mathematics curriculum committee to develop a district scope and sequence. During this process, I developed a deeper understanding of the sequence of developing mathematics skills and how they connect.

At that point, I evaluated my own beliefs about teaching mathematics, and through this process, I developed an understanding of the need to build conceptual knowledge alongside procedure knowledge. Finally, I transitioned into a departmentalized classroom with a focus on mathematics. In a new grade level, I used the standards-aligned curriculum to provide instruction that was rigorous, standards-aligned, and developed both procedural and conceptual knowledge. Because I have experienced the challenge of providing high-quality instruction at the elementary level, I am personally invested in addressing this problem of practice for my colleagues.

Study Purpose

This study seeks to understand the instructional materials teachers used to plan for mathematics instruction and the mathematical quality of instruction enacted in K-2 classrooms at Hillside Elementary School. The findings were used to generate recommendations to support future curriculum initiatives and professional learning opportunities (PLO), with the objective of improving mathematics instruction in K-2 classrooms to potentially increase student achievement. The following serve as the research questions:

- What instructional materials do K-2 teachers report using to plan mathematics instruction at Hillside Elementary School?
- What is the observed quality of mathematics instruction in K-2 classrooms at Hillside Elementary School?
- What is the relationship between observed mathematics instructional quality and the instructional materials K-2 teachers used to plan mathematics instruction at Hillside Elementary School?

Conceptual Framework

The conceptual framework that guided this study is based on a reconceptualized framework for ‘opportunity to learn’ proposed by Walkowiak and colleagues (2017), which illustrates specific conditions of instruction that evidence suggests influence students’ opportunities to learn mathematics. Their framework includes four dimensions: Teacher’s Mathematical Knowledge for Teaching (MKT), Time Utilization, Mathematical Tasks, and Mathematical Talk. They posit these dimensions will influence students’ opportunities to develop or build conceptual knowledge.

I have adapted this framework to represent variables that influence instructional quality in a mathematics classroom (see Figure 1.1). Specifically, I’ve separated dimensions between the teacher as an individual and the act of teaching, while adding the school context as a larger mediator for the framework. These adjustments acknowledge that teaching is complex and that there are many variables that might influence high quality mathematics instruction (Cohen et al., 2003). In addition, the goal of this study is to understand a problem of practice within a specific school context, so it is necessary to include this within the conceptual framework. The arrows in the figure do not represent a cause-and-effect relationship; instead, they are there to highlight the complexity of relationships between variables. For example, teachers’ beliefs and attitudes mediate how they use instructional materials to select/adapt/create a mathematical task (Remillard, 2000). If a teacher believes that developing procedural knowledge is more important than conceptual knowledge, they might select activities from the instructional materials that develop students’ procedural knowledge of mathematics and omit activities that develop students’ conceptual knowledge of mathematics.

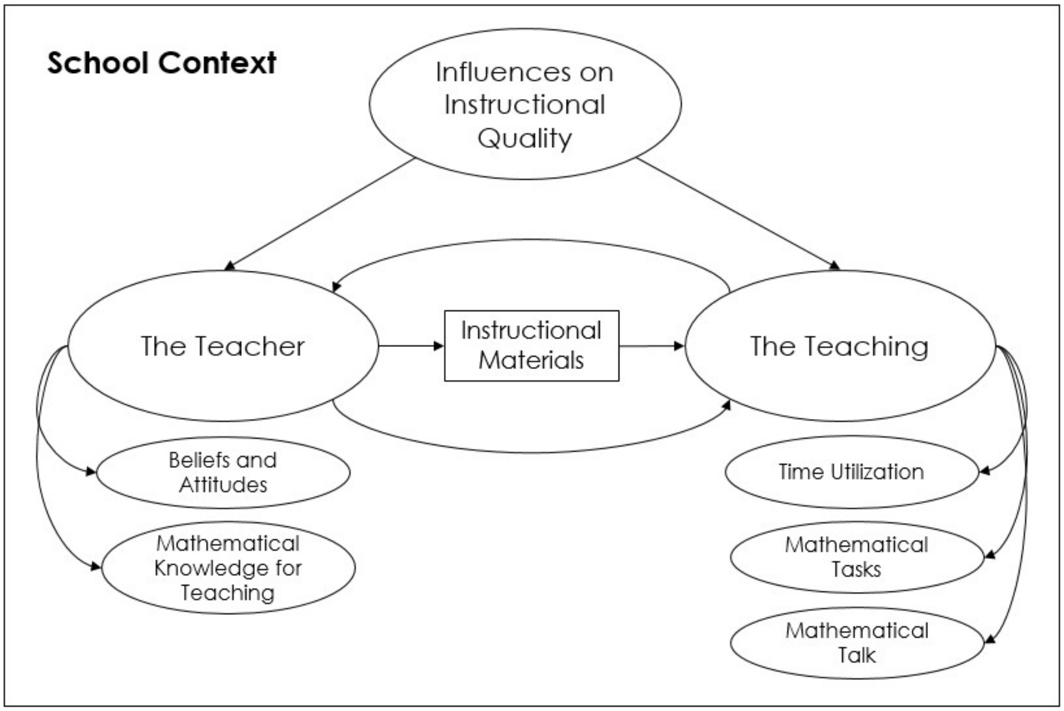
This study will only examine the variables of teaching for two main reasons. First, Hiebert and Stigler (2017) argue that a focus on teaching provides the greatest opportunity for implementing systematic change. The goal of this study is to address a problem of practice to support change within a school system. Second, because of a small sample size, it would be difficult to maintain participant confidentiality with teacher-level data about MKT and teachers' beliefs and attitudes towards mathematics. Also, it is a close school community where staff openly discuss their beliefs and attitudes towards mathematics with colleagues and administrators. Using this information in my findings might create unwanted opportunities for participant identities to be determined. I will share the findings and recommendations with the building principal and director of curriculum and instruction, so it is important to protect participant confidentiality.

Furthermore, there are many aspects of instructional quality that I do not focus on in this study. Those include, but are not limited to, cultural responsiveness, students' prior knowledge, and student motivation and engagement. I strategically focused on the teaching and not the students because the purpose of addressing this problem of practice, from the district's perspective, is to support teachers by selecting a high-quality curriculum and implementing it well to improve instructional quality. Also, my conceptualization of instructional quality aligns with Walkowiak and colleague's (2018) and Hill's (2008) work and this framework and measure foregrounds the aspects of instruction focused on for this Capstone.

In the rest of this section, I explain each variable in my conceptual framework of instructional quality: school context, the teacher, and the teaching. Next, I connect this conceptual framework to the problem of practice. This conceptual framework informed the methodology, findings, and recommendations for this study (see Figure 1.1).

Figure 1.1

A Framework for Instructional Quality



School Context

The school context sets the stage for teachers and teaching (Cohen et al., 2003). District policies, school administration, resources and more can impact the teacher and teaching. For this study, district policies are policies that are school board approved and provide guidelines that inform how teachers can teach in the classroom. Cohen and colleagues (2013) define resources as money or things that money can buy (e.g., curriculum materials, buildings, teachers, etc.). For example, Hillside Elementary School has a district approved curriculum, *enVisionMath*, which is a resource that can support teaching. However, the district does not have a policy that provides guidelines for implementation. Instead, the building level principal has communicated to teachers that they can use the curriculum or select their own instructional materials as long as they teach the grade-level academic standards. Because of financial limitations, PLO are infrequent, and the district does not employ a mathematics instructional coach. Consequently, the findings and recommendations of this study were situated in the school context. For example, I developed recommendations by considering the limitations of the school context and the feasibility of implementation.

The Teacher

Additionally, it is important to acknowledge that the teacher influences classroom instruction in a variety of ways (Hiebert & Grouws, 2007; Walkowiak et al., 2017). Teachers' beliefs and attitudes towards mathematics can challenge the consistent enactment of high-quality mathematics instruction (Ernest, 1989; Evans et al., 2013). Wilkins' (2008) correlational study found a strong connection between teachers' beliefs about models of instruction and the selection of instructional practices. For example, if teachers believe that inquiry-based instructional approaches are most effective, they will use this approach in their classroom. Other researchers have observed an inconsistency in teachers' beliefs about the best model of instruction and the recommendations for best mathematical practices provided by NCTM (Ellis & Berry III, 2005; Wright, 2012). Teachers often prioritize development of procedural knowledge, using skill-and-drill worksheets, instead of focusing on the development of conceptual knowledge.

Moreover, teachers' attitudes towards mathematics can influence how they present content (Wilkins, 2008). Riggs and colleagues (2018) linked teachers with high self-efficacy (i.e., belief in their ability to teach mathematics) to higher student achievement in their classrooms. They argue that teachers' attitudes towards mathematics can directly influence their behaviors and instructional practices. Wilkins (2008) suggests that teachers' beliefs and attitudes "ultimately shape instruction" (p. 157). Thus, teachers' beliefs and attitudes are an important variable that influences instructional quality.

Teachers' MKT impacts a teacher's ability to utilize instructional materials (Hill & Charalambous, 2012a) and/or create conditions for high-quality teaching (Walkowiak et al., 2017). Researchers define MKT as the ability to calculate mathematical problems correctly, conceptually represent mathematics using pictures and diagrams, provide clear and correct explanations for rules and procedures, and evaluate students' solutions (Hill et al., 2005). Hill and Charalambous (2012) conducted a comparative case study and found that MKT is required to interpret the curricular materials and to connect student ideas to mathematical concepts. Additionally, Walkowiak and colleagues (2017) argue that teachers with deep MKT can use accurate mathematical language and select appropriate representations without promoting student misconceptions. MKT is an important variable that can support instructional quality, so the conceptual framework acknowledges that teachers' MKT and beliefs and attitudes influence teaching.

However, for the scope of this study, I did not measure teachers' beliefs and attitudes or MKT. This decision is based on the following reasons. First, it would be difficult to maintain confidentiality of teachers' MKT with a small sample size. Second, teachers' beliefs and attitudes are difficult to change. To address the problem of practice, this study focuses on teaching to support system level change. Lastly, teaching is complex in nature and it would be difficult to measure all aspects of instruction quality in one study. Nonetheless, it is important to acknowledge these variables in the conceptual framework because the findings will not consider teachers' beliefs and attitudes or MKT, which creates boundaries on the interpretation of the findings.

The Teaching

Using the framework of Walkowiak and colleagues (2017) as a guide, I examined teaching using three dimensions: Time Utilization, Mathematical Tasks, and Mathematical Talk (see Figure 1.1). In addition, these dimensions also align with the 2014 Mathematical Quality of Instruction (MQI) observation instrument, which was used to measure the observed quality of mathematics instruction for this study. The MQI is a systematic observation instrument designed to measure the mathematical content available to students during instruction (Hill et al., 2012). The tool includes 21 segment codes organized into four dimensions: *Richness of the Mathematics*, *Working with Students and Mathematics*, *Errors and Imprecision*, and *Common Core Aligned Student Practices*. The tool also includes ten whole-lesson codes. While I did not organize the dimensions in the same way, each indicator of the MQI fits into Time Utilization, Mathematical Tasks, and Mathematical Talk. In the next section, I will discuss each of these categories individually and provide examples of alignment with the MQI.

Time Utilization

High-quality mathematics instruction requires adequate time and the appropriate use of time (Hill et al., 2012). Carroll (1963) argues that students need adequate time to engage in mathematical tasks. Teaching should focus instructional time on the “act of learning” (p. 725). Later research confirms that more time to engage in quality mathematics instruction supported student achievement (Ottmar et al., 2014). Three MQI indicators measure the quality and quantity of time use during mathematics instruction: *Classroom Work is Connected to Mathematics*, *Lesson Time is Used Efficiently*, and *Lesson is Mathematically Dense*. The first two indicators capture if the lesson is focused on mathematical work. The third indicator measures the density of mathematical content covered during instructional time.

Mathematical Tasks

The mathematical task describes the content and execution of instruction. Implementation of mathematical tasks includes three stages: planning of the task using instructional materials, teacher enactment of the task, and student engagement with the task (Stein & Smith, 1998). Walkowiak and colleagues (2017) describe the important characteristics of mathematical tasks as student-focused, with opportunities for sense-making and use of two or more representations. Mathematical representations, such as drawings, words, and/or physical objects, illustrate mathematical constructs and actions (NCTM, 2014). One example of an opportunity for sense-making is the extent to which the teacher or students make connections between a mathematical idea and a representation to develop conceptual knowledge. The MQI measures the richness of a mathematical task with three indicators: *Mathematical Sense-Making*, *Linking Between Representations*, and *Task Cognitive Demand*.

Mathematical Talk

Finally, the mathematical talk of teachers and students is an additional facet of instructional quality (NCTM, 2014; Walkowiak et al., 2017). NCTM (2014) recommends that mathematics teachers should support students in engaging in meaningful mathematical talk to build a deeper understanding of the instructional content. Walkowiak and colleagues (2017) describe mathematical talk using two characteristics. First, students should be able to explain their thinking. Second, mathematical talk should develop a deeper understanding of the lesson objective. The MQI measures mathematical talk with five indicators. The first indicator is *Explanations,* which is aligned with the second characteristic of Walkowiak and colleagues' conceptualization of mathematical talk. Second, the MQI measures mathematical talk with the *Mathematical Language* indicator. At the high level, students should use sophisticated mathematical vocabulary to explain their thinking. The final three indicators that measure

Mathematical Talk include *Students Provide Explanations*, *Student Mathematical Questioning and Reasoning*, and *Students Communicate about the Mathematics of the Segment*. These indicators address both of the characteristics of mathematical talk described by Walkowiak and colleagues (2017).

Instructional Materials

Researchers have found the instructional materials can mediate the quality of instruction provided to students. More specifically, Remillard (2000) found that the enactment of curriculum is subject to teachers' beliefs about mathematics and how students learn. Additionally, she found that some teachers used instructional materials to help develop their subject-specific knowledge. For example, one teacher improved the accuracy of mathematical language used during instruction and selected and implemented standards-aligned mathematical tasks. Another teacher adapted or modified instructional materials if they did not align with their beliefs about mathematics. In this case, the teacher held the belief that procedural knowledge is more important than conceptual knowledge. Therefore, this teacher selected the procedural knowledge practice problems from the curriculum and ignored the mathematical tasks that built conceptual knowledge. Remillard (2000) suggests that the instruction in this teacher’s classroom provided limited opportunities for mathematical sense-making, which negatively impacted instructional quality.

Along with this, evidence suggests that standards-aligned instructional materials improve student achievement outcomes (Reys et al., 2003) and learning opportunities (Trafton et al., 2001). Instructional materials are a tool that can support the development of the teacher and the quality of enacted instruction in the classroom. Therefore, it is important to include instructional materials as one of the many variables which influence instructional quality in mathematics.

The 2019 American Instructional Resources Survey (AIRS) was used to evaluate the instructional materials teachers used to plan mathematics instruction. Survey responses describe the instructional materials teachers used to plan mathematics and if these materials are rigorous and standards-aligned (Opfer et al., 2018). Collecting evidence about how teachers are using instructional materials will support systematic inquiry to understand the relationship between how teachers use instructional materials and how this might support or hinder the mathematical quality of instruction.

Connections to Problem of Practice

Hillside Elementary School provides some guidelines for time utilization and mathematical tasks. However, the district has no guidance for mathematical talk. They allot K-2 elementary teachers 50-60 minutes each day for mathematics instruction. This does not account for transition time between specials, recess, lunch, and so on. The district provides teachers with a district scope and sequence and the *enVisionMath* mathematics curriculum to use for planning instruction. Using *enVisionMath* is optional. The scope and sequence document provides guidance on the order to instruct grade-level standards, content vocabulary, and essential questions. Teachers may use the provided curriculum or find/create their own instructional materials using other sources such as *Teachers Pay Teachers (TPT)*. Teachers are only required to cover the state standards. The expectation is that teachers will use their professional judgement to determine the order to teach the mathematics standards, and the strategies used to execute instruction.

Additionally, the district provides individual teachers with a materials budget of approximately $150 which can purchase *TPT* content, workbooks, and math manipulatives along with other school supplies (e.g., pencils, dry erase markers, folders, etc.). Most teachers have basic math manipulatives in their classroom (e.g., base-ten blocks, pattern blocks, uni-fix cubes, rulers, counting chips, etc.). The conceptual framework provided in Figure 1.1 focuses this study on teaching with the goal of understanding how K-2 teachers at Hillside Elementary School utilize time, plan and enact mathematical tasks, and engage in and support mathematical talk over multiple lessons.

Definition of Terms

In this section, I define terms used throughout this capstone.

- Conceptual Knowledge - Conceptual knowledge is knowledge about concepts and principles (Baroody & Ginsburg, 1986). Researchers identify two types of relationships that characterize this knowledge: (1) a connection between two pieces of existing knowledge and (2) a connection between a new piece of information and existing knowledge (Hiebert & LeFevre, 1986). This knowledge is implicit or explicit and can be about abstract or general principles (Rittle-Johnson, 2017).
- Instruction – Instruction is the interaction between teachers, students, and content within a school context (Cohen & Ball, 2001). Specifically, teachers interact with content (e.g., instructional materials) to plan and execute instruction and teachers interact with students during enactment of instruction. Students interact with content (e.g., instructional materials) during mathematics instruction and students interact with teachers during mathematics instruction. These interactions are situated within specific contexts informed by district-policies about instructional material use (e.g., state standards, instructional materials, etc.).
- Instructional Materials – Instructional materials are the materials teachers use that "serve as daily guides" for planning and enacting instruction (Trafton et al., 2001, p. 259). This

can include, but it is not limited to, individual worksheets, classroom activities, and/or comprehensive curriculum guides.

- Mathematical Quality– Mathematical quality refers to the features of mathematics closely related to the work of teaching, like connecting multiple representations, and the distinct characteristics of those features (Learning Mathematics for Teaching Project [LMTP], 2011).
- Procedural Knowledge – Procedural knowledge is knowledge about the steps or actions that need to be taken to accomplish a mathematical goal (Rittle-Johnson, 2017). Researchers categorize surface level procedural knowledge in two separate parts: (1) the symbolic representation system of mathematics and (2) the algorithms for completing mathematical tasks (Hiebert & LeFevre, 1986). Deep procedural knowledge is the ability to integrate symbolic representations and algorithms to flexibility and critically apply mathematical procedures to a given mathematical task (Star, 2005).
- Standards-Aligned Curricula – Standards-aligned curricula is a comprehensive instructional material aligned to a specific set of learning standards (Trafton et al., 2001). Content experts develop teacher guides, student practice pages, and learning activities, and the curriculum has undergone peer review. Curriculum refers to instructional materials that serve as "guides or other resources that teachers use when designing instruction and deciding what will be enacted in the classroom." (Remillard, 2005, p. 213).

Chapter 2: Literature Review

In Chapter 1, I provided an introduction to the problem of practice and outlined the conceptual framework that was used as a lens for understanding the problem of practice addressed by this Capstone. In Chapter 2, I explore the literature that frames my understanding of the problem of practice and informed the methodology of this study. This literature review examines the following: 1) high-quality mathematics instruction, 2) how teachers use instructional materials, and 3) the relationship between instructional materials and mathematical quality. First, it is important to understand features of high-quality mathematics instruction to conceptualize the characteristics of mathematical tasks, mathematical talk, and time utilization needed to provide high-quality student opportunities to learn mathematics. Next, the way teachers use instructional materials provides insights into how this might influence enacted instruction. Finally, the relationship between instructional materials and mathematical quality illustrates how teachers' decisions about instructional materials inform the enacted quality of instruction. I conceptualize instruction as the interaction between teachers, students, and instructional materials, in specific contexts (Cohen et al., 2003). This literature review provides background information needed to understand the problem of practice at Hillside Elementary School.

Inclusion / Exclusion of Articles

It is important to select and evaluate literature critically before conducting and synthesizing research (Creswell & Guetterman, 2019). The following search engines were used to find literature for this review: Google Scholar, APA PsycINFO, and ERIC (EBSCO). Key terms helped narrow the search to find relevant literature. For example, some search terms used for this review include mathematical quality of instruction, instructional practices, instructional materials, teacher-tool relationship, and teacher-created curricula. I included articles if participants were in early, elementary, or middle grades, and the literature was peer-reviewed. Finally, I identified the remaining sources using reference lists of articles found using the search engines.

Mathematical Quality of Instruction

Providing high-quality mathematics instruction at the elementary level is a challenging and complex task (Biech, 2017; Clements et al., 2013; Cobb & Jackson, 2011). Nevertheless, it is an important task because early mathematics achievement for primary grade students can be one indicator of future academic success (Duncan et al., 2007; Watts et al., 2014). Some researchers argue that elementary teachers, as trained generalists, need subject specific feedback to improve their instructional practice (Hill & Grossman, 2013). However, the evaluation tools used to measure instructional quality are often broad tools which do not provide specific, targeted feedback to support teacher development. In this section, I describe high-quality mathematics instruction and provide justification for the subject-specific observation instrument that was used to evaluate the mathematical quality of instruction for this study (i.e., MQI).

High-quality mathematics instruction should create conditions for students to develop mathematical proficiency (Walkowiak et al., 2017). According to the NRC (2001), mathematical proficiency comprises several interwoven competencies: conceptual knowledge, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Conceptual knowledge is the concepts and/or principles that are characterized by connected and meaningful pieces of knowledge. (Hiebert & LeFevre, 1986; Rittle-Johnson, 2017). Procedural knowledge is the knowledge of steps or actions that need to be taken to accomplish the mathematical goal (Rittle-Johnson, 2017; Star, 2005). Strategic competence refers to the ability to use mathematical representations to solve problems (NRC, 2001). Productive disposition is the continued belief that mathematics is an important content area of study and the belief in one's own ability to learn mathematics (Boaler, 2002; Schoenfeld, 1992). Adaptive reasoning is the ability to use procedural and conceptual knowledge flexibility to solve novel mathematical problems (Baroody, 2003). In the remainder of this section, I discuss instructional practices that support development of mathematical proficiency.

Researchers agree that teachers' instructional practices influence the mathematical quality of instruction (Hiebert & Grouws, 2007; Walkowiak et al., 2017). As noted in my conceptual framework, I broadly describe the features of high-quality mathematics instruction using three categories: 1) mathematical tasks, 2) mathematical talk, and 3) time utilization (Walkowiak et al., 2017). More specifically, NCTM (2014) recommends eight teaching practices that teachers can use to provide high-quality mathematics instruction (see Table 2.1). These teaching practices can support enactment of mathematical tasks, meaningful mathematical talk, and focused instructional time. In the next section, I describe the connection between the conceptual framework described in chapter one and NCTM's (2014) Mathematics Teaching Practices.

Table 2.1

Mathematics Teaching Practices from NCTM (2014)

Mathematical Practices
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.

Mathematical Tasks

A mathematical task encompasses how instruction is planned and enacted by the teacher (Stein & Smith, 1998). Mathematical tasks should build procedural fluency from conceptual knowledge, promote reasoning and problem solving, use and connect representations, and support productive struggle in learning mathematics (NCTM, 2014). In this section, I discuss mathematics teaching practices that teachers can use to support students when working on cognitively demanding mathematical tasks.

Build Procedural Fluency from Conceptual Understanding. Historically, researchers have debated the order in which children acquire conceptual and procedural knowledge (Baroody, 2003; Rittle-Johnson & Siegler, 1998). Also, there is a continued controversy over the type of knowledge that is more important for students' academic success (Ellis & Berry III, 2005; Schoenfeld, 2004; Wright, 2012). In the 1980s, educators and researchers were seeking to address the poor mathematics performance of students in the United States. As a result, there was a paradigm shift from a belief that mathematics is a set of unrelated, procedural facts and skills students should memorize to a belief that mathematics is a set of related facts, skills, and procedures students should understand deeply. Researchers combined mathematical theory with theories of learning to develop reform mathematics approaches, which position the development of conceptual knowledge as a priority over the development of procedural knowledge (Ellis & Berry III, 2005). Furthermore, NCTM (2014) recommends that teachers should "build procedural fluency from conceptual understanding" (p. 10). They agree that both types of knowledge are important, but their statement suggests that a concept-first approach is ideal. In this section, I discuss the empirical evidence that provides insight into the relationship between conceptual and procedural knowledge.

Currently, there is a consensus that both procedural and conceptual knowledge are important for students to reach mathematical proficiency (Davis, 1986; Hurrell, 2021; NCTM, 2014; NRC, 2001; Rittle-Johnson, 2017). Yet, there are varying theoretical viewpoints about the relationship between conceptual and procedural knowledge (Rittle-Johnson & Siegler, 1998; Schneider & Stern, 2010). The concepts-first view suggests that the relationship is unidirectional with conceptual knowledge leading to procedural knowledge. The procedures-first view suggests the opposite is true. The iterative model theorizes that the relationship is bidirectional (Rittle-Johnson et al., 2001). Finally, some researchers believe that the conceptual and procedural knowledge might not be related (Schneider & Stern, 2010). However, the iterative model is the most widely accepted theoretical viewpoint among many researchers today (Hurrell, 2021; Rittle-Johnson, 2017; Rittle-Johnson & Schneider, 2014).

The Iterative Model. The iterative model suggests that conceptual and procedural knowledge are positively correlated (Rittle-Johnson et al., 2001; Rittle-Johnson & Schneider, 2014; Rittle-Johnson & Siegler, 1998). Furthermore, Rittle-Johnson & Schneider (2014) provide a synthesis of current research about the relationship between conceptual and procedural knowledge. They posit that there is a general consensus that the relations are frequently bi-directional and iterative. This view of knowledge development supports gradual improvements in both types of knowledge and recognizes that knowledge is multifaceted and complex (de Jong & Ferguson-Hessler, 1996; Silver, 1986). Additionally, with the iterative model, concepts-first or procedures-first development pathways are acceptable because initial knowledge can be conceptual or procedural. Finally, this model supports the idea that gains in one type of knowledge support gains in the other type of knowledge. Therefore, high-quality mathematics instruction should develop both conceptual knowledge and procedural knowledge.

Promote Reasoning and Problem Solving. To promote reasoning and problem solving, mathematical tasks should be contextualized by using real-world situations and they should make explicit connections between conceptual and procedural knowledge. Researchers have categorized mathematical tasks by the level of cognitive demand required to complete the task (see Table 2.2; Stein et al., 1996; Stein & Smith, 1998; NCTM 2014). At the high level, students are working to develop deep conceptual knowledge and make connections between conceptual and procedural knowledge. At the low level, students are using procedural knowledge to provide correct answers to mathematics problems. High-quality mathematics instruction includes high-cognitive demand tasks that support the development of conceptual and procedural knowledge.

Table 2.2

Levels of Cognitive Demand From Stein and Smith (1998)

Task Category	Cognitive Demand	Typical Characteristics
Doing Mathematics	High	• Explore mathematical concepts to understand mathematical relationships, patterns, and generalizations • Require complex thinking by not providing a specific solution pathway or algorithm • Require students to apply prior knowledge to task context • Supports productive struggle
Procedures with Connections	High	• Use procedural knowledge to develop deeper conceptual knowledge • Provide explicit or implicit solution pathways to broader conceptual ideas • Use multiple representations and require connections to be made between representations • Supports some productive struggle
Procedures without Connections	Low	• Use procedural knowledge to apply an algorithm • Focused on correct answers • Limited connections to underlining concepts
Memorization	Low	• Reproduce facts, rules, formals, or definitions • Focused on memorizing procedural knowledge • No connections to underlining concepts

Support Productive Struggle in Learning Mathematics. Productive struggle supports students' development of conceptual knowledge and supports students' ability to persist in solving challenging math problems (Hiebert & Grouws, 2007). For that reason, classroom activities, like mathematical tasks, need to allow for productive struggle. Struggle is productive when students make progress towards making sense of the mathematics and developing conceptual understanding (NCTM, 2014). Struggle is unproductive if students do not do the work of sense-making or if teachers do not provide feedback to support sense-making.

There are things teachers can do to scaffold student understanding when they are working on challenging mathematical tasks. First, teachers can draw explicit connections between different representations, so students can explore different ways to solve a problem (Huinker & Bill, 2017). Second, teachers can use students' lived experiences to apply mathematics to real-world situations, so students can use their prior knowledge to engage in mathematics. Next, teachers can monitor student meaning-making by providing conceptual feedback. This feedback supports students in making progress towards learning goals. Finally, when teachers ask students to justify and explain their thinking, they are moving students beyond finding the correct answer and requiring them to use conceptual knowledge to explain their thinking. In using these strategies, teachers make struggle more productive, in that students are not just sitting there not knowing what to do but developing a repertoire of strategies they can employ when they face hard problems.

Teachers can also make struggle less productive or eliminate struggle completely (Huinker & Bill, 2017). For example, if a teacher focuses only on correct answers, the focus for students shifts from sense-making to getting the correct response and the work of mathematics in not about actually understanding the mathematical problem. Second, a teacher eliminates struggle when they take over the task as soon as students struggle, instead of providing feedback or scaffolding. For example, a teacher might overly scaffold the mathematical task by telling students how to solve a "Doing Mathematics" task step-by-step. Ultimately, this instructional decision has taken away the opportunity for productive struggle completely. Providing opportunities for students to engage in productive struggle is a key component of high-quality mathematics instruction.

Use and Connect Mathematical Representations. Mathematical representations are visual, physical, contextual, symbolic, or verbal illustrations of a mathematical idea (NCTM, 2014). Representations provide an entry point for students to develop conceptual understanding and procedural fluency. By linking different representations of mathematical ideas, students can develop connections and see patterns between mathematical ideas. For example, students can use physical manipulatives, such as base ten blocks, to model how to solve an addition with regrouping problem. Next, teachers can make explicit connections between the physical representation (base ten blocks) and the symbolic representation (equation) to help students understand the procedure for solving addition with regrouping problems. Finally, representations create opportunities for students to engage in sense-making and mathematical discourse.

Mathematical Talk

High-quality mathematics instruction should include opportunities for students to communicate about mathematics (Walkowiak et al., 2017). Mathematical talk between students is associated with student achievement (Clements et al., 2013), and NCR (2001) argues that in order for students to become mathematically proficient, they need to develop adaptive reasoning, which is defined as the "capacity for logical thought, reflection, explanation, and justification" (p. 5). Therefore, high-quality mathematics instruction should include mathematical talk.

Facilitate Meaningful Mathematical Discourse. A wide range of studies detail the positive benefits of mathematical discourse for students' sense of agency as doers of mathematics to their achievement on standardized assessments (Esmonde & Langer-Osuna, 2013; Kosko, 2012; Stein et al., 2008). Hufferd-Ackles and colleagues (2004) describe the characteristics of mathematical discourse in the classroom using Levels 0-3. At the high-level (3), students lead the discussion and the teacher acts as a guide. Students initiate conversation with other students, and they build on one another's thinking by explaining their thinking. At the mid-level (1-2), the teacher leads the mathematical discussion, asks students questions to deepen student understanding, and probes for student explanations of thinking. At the low-level (0), the teacher does the majority of talking, questions are limited to one- or two- word responses, and the teacher asks questions to elicit the correct response. Based on this description, it is important to consider how the teacher and the student participate in mathematical talk.

Teacher Mathematical Talk. To support Level 3 mathematical discourse, teachers need to pose purposeful questions. Researchers have provided a framework describe the different types of questions teachers ask during mathematics instruction (see Table 2.3; NCTM, 2014; Huinker & Bill, 2017). Each question provides different student opportunities to engage in mathematical talk. Thus, teacher mathematical talk informs student opportunities for mathematical talk.

Teachers can use mathematical talk to elicit and use evidence of student thinking (Huinker & Bill, 2017). Eliciting and using student responses allows teachers to gauge mastery of mathematics concepts and provide targeted feedback. Teachers provide feedback in response to student errors, to explain mathematical ideas, and to scaffold student discourse opportunities. Ultimately, teacher's mathematical talk contributes to the quality of mathematics instruction.

Table 2.3

Five Question Types Used in Mathematics Instruction from Huinker and Bill (2017)

Question Type	Purpose
Gathering Information	• Lower-level knowledge • Recall facts, procedures, definitions
Probing Thinking	• Mid-level knowledge • Explain, elaborate, or clarify student thinking
Making the Mathematics Visible	• Mid-level knowledge • Make connections between mathematical ideas and relationships
Encouraging Reflection and Justification	• High-level knowledge • Argue the validity of student work
Engaging with the Reasoning of Others	• High-level knowledge • Co-construction of mathematical knowledge

Student Mathematical Talk. Ball and Bass (2003) suggest that mathematical talk provides opportunities for students to engage in mathematical reasoning, positing that mathematical reasoning is "fundamental to knowing and using mathematics" (p. 29). They suggest students can use mathematical talk to engage in mathematical reasoning for justification. Through this justification, students gain procedural fluency and develop conceptual understanding, which allows them to engage in adaptive reasoning.

Rittle-Johnson (2017) recommends self-explaining as a form of mathematical talk to promote sense-making of new information. Through sense-making, students can improve their conceptual understanding and procedural fluency. Specifically, self-explanations are student generated explanations to support one's own understanding of a new concept (Rittle-Johnson et al., 2017). These explanations support students' ability to integrate new knowledge into their schema while making connections between knowledge. Rittle-Johnson (2006) evaluated if self-explanation supports transfer success of mathematical equivalence for third- through fifth-grade students. She found that self-explanation promoted transfer, but it did not support greater improvements in conceptual knowledge.

Conversely, McEldoon and colleagues (2013) found that self-explanations during second grade addition instruction promoted both conceptual and procedural knowledge development. They argue that self-explanation supported conceptual knowledge by focusing the learner on explaining the underlying concepts of the mathematical problem. Additionally, they suggest repeatedly explaining the procedure improves students' procedural knowledge and their ability to transfer the procedure to other problems. At the same time, this practice might support the invention of new procedures. Finally, Hiebert and Grouws (2007) identified the importance of providing learning opportunities for students to make connections between types of knowledge. This evidence suggests that high-quality instruction includes students providing explanations, questioning and reasoning, and communicating about mathematical ideas through mathematical talk.

Time Utilization

Additionally, effective instruction requires a teacher to allocate enough time for students to engage meaningfully with the mathematical task (Ottmar et al., 2014; Walkowiak et al., 2017). According to NCTM's recommendations, students should receive at least one hour of instruction focused on mathematics each day (NCTM, 2006). Ottmar and colleagues (2014) evaluated the quality and exposure of mathematics instruction related to student achievement. Using standards assessment measures, they found that teachers who provide more time on mathematics had increased student outcomes, regardless of instructional quality. This illustrates that the density of the mathematical work in a lesson matters and it is important to measure how teachers utilize time during mathematics instruction.

Establish Mathematics Goals to Focus Learning. High-quality mathematics instruction focuses on mathematics goals aligned to grade-level standards (Hiebert & Grouws, 2007). The mathematics goals should "describe what mathematical concepts, ideas or methods students will understand more deeply as a result of instruction and identify the mathematical practices that students are learning to use more proficiently" (NCTM, 2014, p. 12).

The studies cited above help provide a broad architecture for analyzing features of mathematical quality. Most of the mathematics education literature referenced in this section is small-scale, descriptive, and focused on a purposeful sample. However, I relied heavily on consensus panel reports, like the NRC (2011) report, which focus on integration across multiple studies. Although mathematics education literature has a long way to go in terms of methodological rigor and large-scale studies, this section represented a wide swath of the extant literature.

Measuring High-Quality Mathematics Instruction

After examining the features of high-quality mathematics instruction, it is necessary to consider how to measure these features. Researchers have done this work by using subject-specific, systematic observation protocols to evaluate the quality of instruction (Boston et al., 2015; LMTP, 2011). Historically, systematic observation protocols used in K-12 contexts have measured teachers' content-generic pedagogical practices, rather than subject-specific features of instruction (e.g., the Danielson Framework) (Hill & Grossman, 2013). Alternatively, subject-specific observation measures enable more nuanced data about the strengths and weaknesses within a particular context and subject-area (Klette & Blikstad-Balas, 2018). Further, these tools provide a common language for discussing instructional practices for individual subject areas, allowing for collaborative reflection of practice within a school context. In this study, I use the

MQI, designed as a mathematics-specific observation tool, as one way to measure mathematical quality in the hopes that the data captured can provide these teachers and this district with targeted and specific feedback needed to improve the quality of mathematics instruction.

The MQI is a systematic observation instrument designed to measure the features of mathematical quality of instruction (Hill et al., 2008, 2012; Hill & Grossman, 2013; LMTP, 2011). The features of mathematical quality identified in this observation instrument align with what previous research suggests are characteristics of high-quality instruction. The MQI measures a variety of important mathematical features of high-quality instruction, including the cognitive demand of a mathematical task, the opportunities for students to talk about mathematics, and the ways teachers use instruction time during mathematics. For example, the MQI measures *Common Core Aligned Student Practices,* including *Task Cognitive Demand* and if students work with contextualized word problems. Also, indicators measure the quality of the teachers' mathematical talk, including the quality and clarity of teacher explanations and use of precise mathematical language. Next, the *Common Core Aligned Student Practices* dimension measures how the conditions of instruction support students' mathematical talk by evaluating students' opportunities to justify and explain their thinking and communicate with peers about mathematics. Finally, indicators measure the quality and density of mathematics during the observed lesson, with the goal of understanding how teachers use instructional time. These dimensions are further discussed in Chapter 4.

Instructional Materials

Though tools like the MQI capture many important features of instruction, classroom observational measures tend not to analyze the quality of the materials teachers are using. As noted in my conceptual framework, instructional materials are another key resource that has the potential to improve mathematical quality of instruction in elementary classrooms (Hill et al., 2015). Instructional materials can support or hinder the mathematical quality of instruction (Hill & Charalambous, 2012a, 2012b). For example, standards-aligned, research-based instructional materials provide high-cognitive demand mathematical tasks, recommend structures for students to communicate about mathematics, and provide student practice pages that are mathematically dense. Researchers have found that standards-aligned instructional materials improve student learning opportunities (Trafton et al., 2001) and student achievement outcomes (Reys et al., 2003). Consequently, it is important to understand the type of instructional materials teachers use (e.g., research-based, teacher-created, etc.) to provide mathematics instruction and the quality of these instructional materials.

Standards-Aligned Curricula

Researchers agree that standards-aligned, research-based curriculum materials support enactment of high quality mathematics instruction (Blazar et al., 2020; Clements & Sarama, 2008; Hill et al., 2015; Koedel et al., 2017; Lynch et al., 2017; Trafton et al., 2001). Trafton and colleagues (2001) identified the characteristics of standards-aligned curriculum materials as:

- comprehensive, covering procedural and conceptual knowledge
- coherent, supporting students in making connections between big mathematical ideas
- complex, developing mathematical ideas in depth while promoting sense-making
- engaging, supporting students' cognitive and physical engagement
- authentic, providing opportunities for real-world application of mathematical skills

These characteristics are aligned with the aspects of high-quality mathematics instruction discussed in the previous section and provide guidance for evaluating the quality of curricular materials used to plan and enact mathematics instruction.

Additional research links standards-aligned curriculum materials with improved student achievement (Hill et al., 2015; Reys et al., 2003). Reys and colleagues (2003) found a statistically significant difference in student achievement outcomes for eighth grade students whose teacher used standards-based instructional materials for two years compared to students whose teacher did not use such materials. Their findings suggest that standards-based instructional materials improve learning outcomes in mathematics. However, the quality and content of curriculum materials used to teach elementary mathematics can vary teacher-to-teacher and school-to-school (Opfer et al., 2018; Polly, 2017). Consequently, it is important to understand what instructional materials elementary teachers are using and the quality of these instructional materials.

Results from several studies indicate teachers use a variety of instructional materials to support instructional goals in the classroom (Hilton et al., 2019; Opfer et al., 2018; Polly, 2017). Polly (2017) administered a survey to determine what curricular materials elementary teachers used to teach mathematics, and he found that a majority of teachers compile a variety of materials to use as a "curriculum." Also, he found that more than half of the materials used were teacher-created and/or internet-based (e.g., *Teachers Pay Teachers*). While he did not evaluate enacted curriculum, this study suggests the importance of determining who has the authority to determine the curricular materials used in a mathematics classroom and the necessity for teachers to be trained in evaluating curricular materials to ensure they are standards-aligned.

Teacher-Created Curricula

Using high-quality curricula is important, but in today's educational marketplace, teachers have access to numerous types of instructional materials that vary in content and quality. Therefore, given the popularity of online marketplaces like *Pinterest* and *Teachers Pay*

Teachers, it is important to consider how teachers use teacher-created curricula and the quality of instructional materials purchased from these sites. Researchers found that *TPT* is the most used platform for selecting supplemental instructional materials (Shapiro et al., 2019). These materials can range from a teacher-created curriculum (including a scope and sequence), unit plans with individual lesson plans to individual, single-day worksheets or activities.

Shapiro and colleagues (2019) explored the frequency with which teachers use free or paid online activities. Results suggest that 30 percent of teachers report using free online materials “most of the time” and 19 percent of teachers report using paid online activities “most of the time” to provide elementary mathematics instruction. Additionally, 21 percent of teachers use free online activities about “half of the time” and 14 percent of teachers use paid online activities about “half of the time” (Shapiro et al., 2019, p. 678). This suggests it is common for teachers to use online marketplaces to replace and/or supplement instructional materials for mathematics instruction, so it is important to understand the quality of instructional materials they select.

Research suggests there are advantages and disadvantages to these online marketplaces. Some researchers argue that these online marketplaces position teachers as global collaborators and teacher-leaders (Grote-Garcia & Vasinda, 2014). Other researchers remind us that these for-profit platforms design their services to earn money with little consideration given to content quality (Polikoff & Dean, 2019; Shelton et al., 2020; Shelton et al., 2022). Shelton and colleagues found that users consistently rate *TPT* products highly (or leave no rating at all). As a result, the rating scale for *TPT* products does not accurately evaluate the quality of a product. This evidence suggests that teacher-authors focus on creating products that will earn a profit and the quality of products is unclear. For example, teacher-authors might focus on adding clip art to student practice pages, creating cut-and-paste craft activities, or gamifying practice opportunities to improve students' behavioral engagement without consideration to students' cognitive engagement.

Specific to content quality, researchers have found that mathematical tasks from these online marketplaces are consistently poor quality (Hertel & Wessman-Enzinger, 2017; Polikoff & Dean, 2019; Sawyer, 2018). After reviewing over 500 resources on *Pinterest*, Sawyer and colleagues (2019) found that most elementary mathematics tasks were lower-level cognitive demand. Further, Polikoff and Dean (2019) reviewed materials from *TPT* and found 10 percent of materials were "very poor" and 62 percent of materials were "mediocre" (p. 11). They also found that most materials were cognitively undemanding and misaligned with provided assessments. Therefore, classrooms that rely heavily on teacher-created curricula, from places like *TPT*, might not foreground rigor, degrading the mathematical quality of instruction.

Last, issues of equity pervade these platforms that perpetuate unproductive and/or harmful beliefs and contribute to already systemic challenges facing teachers (Gallagher et al., 2019; Polikoff & Dean, 2019). For example, one popular teacher-created material is the "QU Wedding." This literacy activity is designed to teach elementary students about the letter combination "qu." The activity typically involves selecting a female student to be the bride and a male student to be the groom. This perpetuates the narrow view that marriage is only between a man and a woman and assumes that marriages do not end in divorce. Adding to this, one percent of the sellers, who created the most frequently sold products on TPT, are characterized as experienced classroom teachers and highly educated white women (Sawyer et al., 2019; Shelton & Archambault, 2019). Popular teacher-authors are not representative of the teacher population nor the diverse populations of students served in the United States. Finally, not all teachers have access to personal or school funds to purchase teacher-created curricula (Shelton & Archambault, 2019). This likely means that under resourced teachers in under resourced schools are less likely to have additional funds to purchase from these marketplaces.

Nevertheless, publishers cannot design instructional materials to meet the unique learning needs of all students in all school contexts (Remillard, 2005; Rich, 2021). Therefore, teachers need to develop Critical Curriculum Literacies, so they can productively adapt and/or modify provided and found instruction materials to support the unique learning needs in their classrooms (Rice & Ortiz, 2021). As a result, researchers have developed checklists and frameworks to support teachers in evaluating and/or modifying potential instructional materials selected to supplement provided materials (Gallagher et al., 2019; Rice & Ortiz, 2021). There is limited research on the effectiveness of these tools in promoting high-quality instruction practices, but they provide important guidelines that teachers can use to develop skilled flexibility in using standards-aligned instructional materials while providing student-centered classroom instruction. Additionally, they provide a way for teachers to practice critical literacy skills when using online marketplaces, such as *TPT*.

Research suggests that most teachers are not using standards-aligned curricula, and even if they are using standards-aligned curricula, each teacher implements the curricula differently (Opfer et al., 2018). Ultimately, this inconsistency in the enactment of curricula is likely to influence the quality of instruction in classrooms. In the remaining section, I discuss the literature about how teachers interact with instructional materials to better understand why there is such variety in teachers' use of instructional materials. High-quality instructional materials alone do not automatically result in improved student achievement (Blazar et al., 2020). Instead, it is important to consider the relationship between how teachers use instructional materials and how their use relates to the observed mathematical quality of instruction.

The Relationship Between Instruction and Instructional Materials

Standards-aligned curricula has the potential to aid teachers in providing high-quality mathematics instruction in elementary classrooms (Blazar et al., 2020; Clements & Sarama, 2008; Hill et al., 2015; Lynch et al., 2017). However, instructional materials are complex and layered (Ben-Peretz, 1990), making them difficult to use consistently from classroom-to-classroom. There are often many components, and teachers do not have adequate training to effectively and consistently implement all the components, so they use materials in idiosyncratic ways (Remillard & Kim, 2017). Therefore, it is important to examine how teachers use instructional materials and how this might influence mathematical quality of instruction.

Teachers engage in several processes to understand curricular materials prior to enacting instruction, such as reading, evaluating, and adapting materials (Remillard, 1999, 2000; Sherin & Drake, 2009). Remillard (1999, 2000) examined the teacher-curriculum relationship and found that curricular materials are “read” differently by different teachers. Teachers engage in "reading" the textbook and "reading" the students. Through the first activity, teachers decide to modify or adapt activities provided in the instructional materials. The second provides an opportunity for teachers to learn how to navigate student misunderstandings and respond to varied solution paths provided by students. She argues that how teachers “read” materials influences the quality of enacted mathematical tasks and how the teacher works with students (e.g., feedback, scaffolding, etc.).

Moreover, Sherin and Drake (2009) evaluated patterns of curricula use and identified three cases to describe how teachers “read” curricula. First, teachers read materials for a broad overview before instruction. Teachers with this pattern of practice reviewed instruction materials to get a general sense of the lesson content, but they did not attend to the detailed information provided about how to enact instruction. Second, teachers closely read the lesson guide before instruction. In this category, teachers carefully reviewed all aspects of the instruction materials, looking for guidance on how to enact the lesson. During the lesson, they did not reference instructional materials. Third, teachers read a broad overview before instruction and detailed information during instruction. These teachers skimmed instructional materials beforehand and then carried materials with them during instruction to read directly from the teacher's guide.

Similarly, Remillard and Bryans (2004) found significant variation in enactment of curriculum, with different teachers focusing on different components of the curriculum. They found that teachers' beliefs and orientations mediated how they implemented the curricular materials. Specifically, teachers who believed mathematics is a set of discrete skills focused on the parts of the instructional materials that supported the development of procedural knowledge, like "skill-and-drill" practice pages. Alternatively, teachers who believed mathematics is a set of connected skills and knowledge focused on parts of the instructional materials that the supported development of conceptual understanding, like contextualized word problems. This suggests that instructional materials are likely not implemented the way the designer intended, and how teachers interact with instructional materials informs the enacted quality of instruction.

Finally, if a teacher elects to adapt curricula materials, they do so in different ways (Ben-Peretz, 1990; Remillard, 2012; Sherin & Drake, 2009). Sherin and Drake (2009) describe three ways teachers adapt or significantly change provided curricula. First, teachers replace components from the provided curricula with self-selected activities. Second, teachers omit components from the provided curricula without replacing the activity. Third, teachers create new components to use with the provided curricula. Regardless of how teachers adapt curriculum materials, when observed over time, teachers interacted consistently with curricula materials, adapting in similar ways from lesson-to-lesson. This is important to consider because a teacher who omits the contextualized word problem during observed instruction will probably omit contextualized word problems during most mathematics lessons. As a result, the lesson activity teachers decide to omit, replace, or create may not align with high-quality mathematics instruction.

While there are numerous benefits to using a standards-aligned curriculum, there are also limitations that need consideration. First, curricular materials do not consider the student or the school context (Remillard, 1999, 2005). Consequently, it is important for teachers to develop the critical literacy skills necessary to interpret and analyze curricular materials and adjust these materials to meet the needs of their students and the school context (Ben-Peretz, 1990). Researchers suggest providing teachers with PLO to learn how to use the many components of instructional materials and deepen their understanding of how these materials support features of high-quality mathematics instruction (Ball & Cohen, 1996; Remillard, 2005).

Second, many teachers believe that a "good" teacher does not use provided instructional materials and instead creates their own tools and activities (Ball & Cohen, 1996; Ben-Peretz, 1990; Remillard, 2016). As a result, teachers elect to use the district-provided curricula with limited fidelity. Instead, they spend planning time, and/or personal time, adding to or replacing curricular materials. It is important to consider the consequences of teachers working individually to make such revisions. Researchers suggest teachers should work collaboratively, with district guidance (Ball & Cohen, 1996), to partner with a standards-aligned curriculum, given that a high-quality curricula was collaboratively written by experts in the field and has undergone a peer review process (Remillard, 2016). In order to do this important work, it is essential that teachers develop critical literacy skills to evaluate, adapt, and modify instructional materials in ways that do not compromise mathematical quality (Gallagher et al., 2019; Remillard, 2005; Sherin & Drake, 2009).

Instructional materials, particularly standards-aligned curricula, can support the enactment of high-quality mathematics instruction, if teachers develop the skilled flexibility and critically literacy skills necessary to read, evaluate, and adapt materials in ways that do not degrade the mathematical quality.

Summary

In this review, I examined the literature describing characteristics of high-quality instruction (NCTM, 2014; NRC, 2001), the types of instructional materials (Polikoff & Dean, 2019; Trafton et al., 2001), and the relationship between the instruction and how teachers use instructional materials (Blazar et al., 2020; Clements & Sarama, 2008; Remillard, 2005; Sherin & Drake, 2009). The literature provides an important lens for understanding the specific problem of practice at Hillside Elementary School, but it is important to acknowledge some limitations. First, most studies are small-scale, descriptive, and focused on a purposive sample. We have limited causal, or large-scale, generalizable evidence about the relationship between instructional quality and how teachers use instructional materials. Second, few of the studies evaluated the relationship between instructional materials and quality of instruction for teachers in kindergarten, first, and/or second grade. The relationship might look different in early grades because younger students require different supports, and these are the grades I focused on for this Capstone. However, this does not diminish the importance of supporting teachers in using high-quality instructional materials as a tool to enhance the quality of mathematics instruction enacted in the classroom.

Providing high-quality mathematics instruction is a complex and challenging task that requires specific knowledge, skills, and dispositions. Moreover, the relationship between the teacher and curricular materials is complex and intertwined with other teacher practices, in addition to being situated within a specific context's policies, resources, and learning community. As a result, it is necessary to evaluate the observed quality of mathematics instruction and explore the instructional choices teachers make when using instructional materials. In the next chapter, I describe the methodology used to measure mathematical quality of instruction, the instructional materials used, and the relationship between how teachers use instructional materials and the enacted quality of instruction.

Chapter 3: Methods

All students should have access to high-quality mathematics instruction. However, district administration identified mathematics as an area of growth at Hillside Elementary School. Therefore, this study explored the instructional materials teachers used to plan mathematics instruction and the quality of mathematics instruction observed in the classroom. This study also described the relationship between instructional material use and mathematical quality of instruction. The findings from this study were used to inform recommendations for future curricular initiatives and PLO. In this section, I discuss the methodology used to answer the following research questions:

1. What instructional materials do K-2 teachers report using to plan mathematics instruction at Hillside Elementary School?
2. What is the observed quality of mathematics instruction in K-2 classrooms at Hillside Elementary School?
3. What is the relationship between observed mathematics instructional quality and the instructional materials K-2 teachers used to plan mathematics instruction at Hillside Elementary School?

Study Design

This descriptive study aimed to understand the quality of mathematics instruction in grades K-2 at Hillside Elementary School. Using a survey, systematic classroom observations, and teacher interviews, the resultant data provided insight into the quality of instruction during mathematics and how teachers used instructional materials to plan and enact mathematics instruction. This was an appropriate design because the aim of the study was to address a problem of practice in a specific context (Creswell & Guetterman, 2019). I designed the research questions to “gather information” and “extend understanding” of the problem of practice (Creswell & Guetterman, 2019, p. 594).

This study was situated within the pragmatic paradigm. Within this paradigm, it is important to select a methodology that best addresses the research questions within the study context (Mertens & Wilson, 2019). First, I answered research question one using a survey that evaluates teachers' use of instructional materials. Next, I answered research question two by collecting and coding three video-recorded observations and analyzing field notes. As part of these observations, I photographed curriculum documents and lesson materials for document analysis. Next, I answered research question three by using data collected from semi-structured interviews and I explored connections across other data sources (i.e., observation results, survey responses, and document analysis). Then, I used document analysis to triangulate the findings (Bennett & McWhorter, 2016). I compared teachers' self-reported use of instructional materials with the documents collected during classroom observations. Finally, I compared the teachers’ interview responses with the observed adaptations and modifications made to the collected documents. The findings from this study will inform future curricular initiatives and PLO offered to K-2 teachers at Hillside Elementary School.

Study Context

Hillside Elementary School is a rural, Title 1 public school located in Pennsylvania that serves 400 students in kindergarten through fourth grade. They employ twenty general education teachers in the building, with four sections in each grade level. Kindergarten through second grade classrooms are self-contained, while third and fourth grade classrooms are departmentalized. Additionally, they employ five special education teachers, two reading specialists, and four special area teachers (i.e., physical education teacher, music teacher, art teacher, and librarian) to provide specialized instruction. The current district-provided mathematics curriculum is *enVisionMath*, but teachers may use any instructional materials if aligned to grade-level standards. The district purchased the following supplemental resources for optional use: *XtraMath* and *IXL*. The district expects self-contained, general education teachers to allot 50-60 minutes of math instruction each day. In the last five years, teachers have not received formal, district-provided PLO to support implementation of the mathematics curriculum (i.e., *enVisionMath*). Currently, the district does not have a curriculum evaluation system. For this study, I did not have access to student data for grades one and two and kindergarten teachers do not collect student mathematics data.

Participants and Sampling

After obtaining approval from Institutional Review Board for Social and Behavioral Sciences (IRB-SBS), I invited all K-2 general education teachers who spend at least 30 minutes providing daily mathematics instruction at Hillside Elementary School to participate in the study (n = 12). I identified a volunteer sample, and six teachers elected to participate in the study: three kindergarten teachers and three second grade teachers. I used this sampling strategy because it reduced recruitment time and improved participant engagement across all stages of data collection (Sharma, 2014). Participants ranged in years of experience (i.e., 8-25 years) and hold a Level II Pennsylvania Teaching Certification. To ensure confidentiality, I gave all teachers a pseudonym. Kindergarten teachers included Ms. Aster, Ms. Bellflower, and Ms. Coriander. Second grade teachers included Ms. Dodder, Ms. Foxglove, and Ms. Hollyhock. Given the small sample size, I did not provide individual demographic data (e.g., years of experience) as this data might be identifying.

Instrumentation

I used several data collection strategies during this study: a survey, a systematic observation protocol, document collection, and an interview protocol. To triangulate data, I collected the instructional materials that teachers used to plan observed lessons and collected field notes. In this section, I describe the survey instrument, observation protocol, and interview protocol.

Survey

For this study, I used the 2019 American Instructional Resources Survey (AIRS) which is an existing, validated survey instrument developed by RAND. Researchers worked with experts to write survey items and select borrowed survey items from other questionnaires (Prado Tuma et al., 2020). They administered the survey to a probabilistic sample of 6,500 teachers and they weighted survey responses to reflect national teacher characteristics. They designed the survey to measure what instructional materials K-12 teachers used to teach mathematics, science, and/or English language arts. Specifically, survey responses describe how teachers use standards-aligned curricula to plan and enact instruction. This aligns with research question one, which seeks to understand teachers' planning practices using instructional materials.

Prior to implementing, I modified the survey by removing sections that did not align with the research questions. As a result, I eliminated five sections. First, I eliminated two non-mathematics subject-specific sections. Second, I eliminated Teacher Preparation Programs because participants are experienced teachers who have not been in a teacher preparation program for several years. Last, I eliminated Standards-Aligned Instructional Content and Approaches and Teacher Beliefs because they did not align with the study purpose. Standards-Aligned Instructional Content and Approaches measures mathematical topics emphasized across different grade levels based on state standards for mathematics. This study did not evaluate teachers' MKT. Also, given the small sample size, grade-level specific survey items would identify participants. Teacher Beliefs focused on beliefs about mathematics standards and it did not focus on features of mathematics instruction or use of instructional materials. In Table 3.1, I list all the sections of AIRS and I highlight the sections used in this study.

Table 3.1

AIRS Sections

AIRS Sections	Sections Used
Your Teaching Assignment	x
Curriculum Materials: English Language Arts	
Curriculum Materials: Mathematics	x
Curriculum Materials: Science	
Professional Learning	x
Teacher Preparation Programs	
Standards-Aligned Instructional Content and Approaches	
Teacher Beliefs	
School Culture	x
Demographics	x

There are several question types included in the five sections of AIRS used in this study (see Table 3.2). The *Your Teaching Assignment* section included one open-ended question and one multiple choice question to determine the participant name and the grade-level they teach. In the *Curriculum Materials: Mathematics* section, survey items request information about what specific instructional materials teachers use with multiple choice, "select all the apply" questions. To determine frequency of instructional material use, survey items are on a scale (e.g., "Just this year", "For the past 2-3 years", etc.). In the *Professional Learning* section, survey items measure who provided PLO for teachers, the frequency of these opportunities, and the extent to which teachers believe the PLO improved how they use their instructional materials. The question types in this section include multiple choice, frequency (e.g., "Never", "1-3 times per year", etc.), and Likert scale (e.g., "Strongly agree", "Somewhat agree", etc.). The *School Culture* section asks teachers to report their perception of school culture using a Likert scale. Finally, the *Demographics* section includes a variety of question types (e.g., multiple choice, open-ended, and select all that apply) to understand demographic information about the teacher and the students in their classroom. The modified survey included 42 survey items.

Systematic Observation Protocol

I used the 2014 Mathematical Quality of Instruction (MQI) observation instrument. This systematic observation protocol measures the mathematical features of classroom instruction (LMTP, 2011). During development, authors evaluated construct validity and conducted a correlational study. Further, they achieved inter-rater reliability that ranged from 65% to 100%. Observation score results address research question two, which seeks to evaluate the mathematical quality of instruction in K-2 classrooms.

The tool features ten whole lesson codes and 21 segment codes (see Table 3.3). Whole lesson codes measure instructional quality across the entire observation, and they designed indicators on a five-point scale. They designed segment codes to measure instructional quality during a seven-and-a-half-minute segment of the lesson. The first segment code: *Classroom Work is Connected to Mathematics* is a dichotomous indicator. Coders select *yes* or *no* based-on instruction observed. They categorized the remaining 20 segment codes into four dimensions: *Working with Students and Mathematics, Errors and Imprecision,* and *Common Core Aligned Student Practices.* Within these dimensions, there are indicators that measure the quality of individual features of mathematics instruction on a four-point scale: not present (1), low (2), mid (3), high (4).

Table 3.2

AIRS Sample Survey Items and Response Options

Section	Survey Item	Response Options
Your Teaching Assignment	This school year (2022-2023), what grade do you teach?	• Kindergarten • Grade 1 • Grade 2
Curriculum Materials: Mathematics	Please complete the following sentence. I typically use lesson plans from my main mathematics material...	• N/A – My main materials do not include lesson plans, or I typically create my own lesson plans • …with no or few modifications • …with modification to less than half of a lesson plan • …with modification to more than half of a lesson plan.
Professional Learning	During this school year (2022-2023) and last school year (2021-2022), how often have you participated in the following types of mathematics professional learning activities. *Workshops or trainings focused on my mathematics teaching and learning* *Workshops or trainings focused on my main mathematics materials* *General (not subject specific) workshops or training* *Coaching focused on my mathematics teaching*	• Never • 1-3 times per year • 4-6 times per year • 1-3 times per month • Weekly or more often
School Culture	Indicate your agreement with the following statements about your experiences at your school during last school year (2021-22). *People in this school are eager to share information about what does and does not work.* *Making mistakes is considered part of the learning process in this school.* *In this school, teachers feel comfortable trying new, research-based teaching approaches.*	• Strongly disagree • Somewhat disagree • Somewhat agree • Strongly agree
Demographics	Indicate your agreement with the following statements about your experiences at your school during last school year (2021-22).	• Total amount of time teaching: ___ • Total amount of time teaching in current state: ___ • Total amount of time teaching in current district: ___ • Total amount of time teaching in current school: ___

Table 3.3

MQI Systematic Observation Protocol: Whole Lesson Codes and Segment Codes

Whole Lesson Codes
1. Lesson Time is Used Efficiently
2. Lesson is Mathematically Dense
3. Students are Engaged
4. Lesson Contains Rich Mathematics
5. Teacher Attends to and Remediates Student Difficulty
6. Teacher Uses Student Ideas
7. Mathematics is Clear and not Distorted
8. Tasks and Activities Develop Mathematics
9. Lesson Contains Common Core Aligned Student Practices
10. Whole-Lesson mathematical Quality of Instruction
Segment Codes
1. Classroom Work is Connected to Mathematics
Richness of the Mathematics
2. Linking Between Representations
3. Explanations
4. Mathematical Sense-Making
5. Multiple Procedures or Solution Methods
6. Patterns and Generalizations
7. Mathematical Language
8. Overall Richness of the Mathematics
Working with Students and Mathematics
9. Remediation of Student Errors and Difficulties
10. Teacher Uses Student Mathematical Contributions
11. Overall Working with Students and Mathematics
Errors and Imprecision
12. Mathematical Content Errors
13. Imprecision in Language or Notation
14. Lack of Clarity in Presentation of Mathematical Content
15. Overall Errors and Imprecision
Common Core Aligned Student Practices
16. Students Provide Explanations
17. Student Mathematical Questioning and Reasoning (SMQR)
18. Students Communicate about the Mathematics of the Segment
19. Task Cognitive Demand
20. Students Work with Contextualized Problems
21. Overall Common Core Aligned Student Practices

Richness of the Mathematics. This dimension captures the depth and richness of mathematics provided during instruction. In this dimension, codes are categorized by codes that capture the meaning of facts and procedures and codes that capture instruction focused on key mathematical practices. *Linking Between Representations*, *Explanations*, and *Mathematical Sense-Making* focus on making meaning of facts and procedures, while *Multiple Procedures or Solution Methods*, *Patterns and Generalizations*, and *Mathematical Language* measure the degree to which instruction includes these key practices.

Working with Students and Mathematics. This dimension measures if teachers respond to and understand students' mathematical contributions or mathematic errors during instruction. Student contributions refer to the questions, explanations, justifications, solution strategies, ideas, etc. Students' mathematical errors are incorrect student contributions. These contributions provide opportunities for the teacher to address the student's difficulty by providing feedback or other supports.

Errors and Imprecision. This dimension evaluates the teacher's mathematical content errors, imprecise use of mathematical language or notation, and clarity of mathematical instruction. Mathematical content errors include, but are not limited to, solving problems incorrectly, providing an incorrect definition, or supporting an incorrect student answer. Imprecise use of mathematical language examines if the teacher misuses mathematical terms, such as "borrowing" instead of "regrouping." Clarity of mathematical instruction seeks to measure if the teacher clearly presented content and the students can understand the concept being presented.

Common Core Aligned Student Practices. This dimension captures the extent to which students are involved in the work of "doing" mathematics. The individual codes in this dimension are aligned with the eight Standards of Mathematical Practices included in the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010):

1. Make sense of problems and persevere in solving problems
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics (addressed by *Students Work with Contextualized Problems*)
5. Use appropriate tools strategically
6. Attend to precision
7. Look for and make use of structure
8. Look for and express regularity in repeated reasoning

While there are not eight codes within this dimension, the MQI evaluates the eight mathematical practices across five codes. For example, *Task Cognitive Demand* measures if students make sense of problems and persevere in solving problems, look for and make use of structure, look for and express regularity in repeated reasoning, and construct viable arguments and critique the reasoning of others.

Time Utilization. Time utilization is measured across multiple MQI codes including *Lesson Time is Used Efficiently*, *Lesson is Mathematically Dense*, and *Classroom Work is Connected to Mathematics*. The *Lesson Time is Used Efficiently* whole lesson code measures the amount of time during the observation window that instruction is focused on developing mathematics. The *Lesson is Mathematically Dense* whole lesson code measures the quality of and density of mathematical content observed during instruction. Finally, the *Lesson Time is*

Used Efficiently segment code measures if seven-and-a-half minute clips are focused on developing mathematics.

Interview Protocol

Last, I developed an interview protocol to understand research question three, the relationship between teachers' use of instructional materials and the observed quality of mathematical instruction. Interview conversations allow researchers to make meaning of participants' experiences and perspectives (Hatch, 2002). Because I wanted to gain a richer understanding of how teachers use instructional materials to plan for mathematics instruction and why they enacted different features of mathematics instruction, I engaged all participants in a one-on-one interview using a semi-structured interview protocol with open-ended questions (see Appendix B). The open-ended structure of the questions allowed me to follow the teachers' lead and generate follow-up questions to explore specific ideas further.

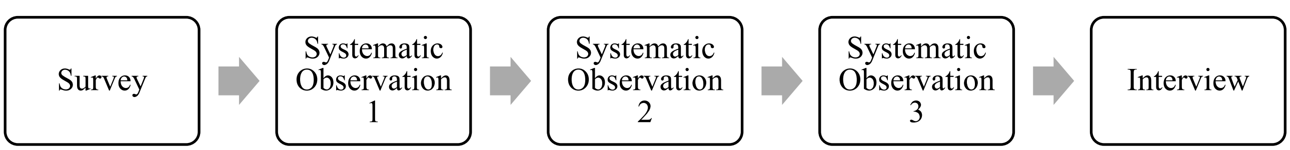
The interview protocol included four sections: *General Background, Instructional Planning, Mathematics Instruction*, and *Teacher's Beliefs and Attitudes*. The *General Background* section asked teachers to describe their typical mathematics block and to explain other mathematics instruction that happened outside the video-recorded lesson (e.g., Calendar Math). This section supported my understanding of how teachers utilized time during mathematics instruction. Next, the *Instructional Planning* section asked teachers to describe the components of *enVisionMath* they used and how they determine supplemental activities. This section triangulated survey results describing how teachers use instructional materials and provided a more complete understanding of how teachers used instructional materials. Then, the *Mathematics Instruction* section asked teachers to justify why they used specific instructional practices during the observed lessons (e.g., multiple representations). This section helped me examine the relationship between enacted instruction and the use of instructional materials. Finally, the *Teacher's Beliefs and Attitudes* section asked teachers to provide their perspective on curriculum related policies, PLO, and how they feel about teaching mathematics. This section was used to inform recommendations.

Data Collection

After receiving the IRB-SBS approval and district administration approval, I completed data collection during the fall 2022 semester. All participants engaged in a three-part data collection sequence. First, they completed the AIRS survey, which took approximately 30 minutes. This provided information about how teachers use instructional materials. Next, I recorded three 30-minute mathematics lessons for each teacher to better understand the quality of mathematics instruction. After recording, I photographed all instructional materials that teachers reported using to plan and enact instruction during the observed lesson. Finally, I interviewed teachers to understand how observed mathematics instructional quality might relate to the use of instructional materials to plan for mathematics instruction. Figure 3.1 illustrates the data collection sequence. In the next section, I describe the data collection process used for each research instrument.

Figure 3.1

Data Collection Sequence



Survey

At the start of data collection, all the K-2 regular education classroom teachers at Hillside Elementary School (n = 12) received a pre-survey notification email which included the procedures to complete the survey, the purpose of the survey, and the request for help in understanding the problem of practice. Two days later, all teachers received an email with a live, personalized *Qualtrics* survey link. For non-responders, I sent the first follow up email two days later, which included a review of the purpose of the survey and the personalized link. The third and final request provided participants with information about how many people have already responded. I sent all emails at 8 a.m. using the email templates included in Appendix A. I had a 50 percent response rate and the six teachers who completed the survey became the volunteer sample for the study.

Observations

Next, I recorded three 30-minute mathematics lessons for each teacher. Hill and colleagues (2011) recommend conducting multiple recordings to increase the validity of the MQI. This aligns with research that suggests multiple recordings capture a more accurate depiction of instructional quality (Hill, Charalambous, & Kraft, 2012). Teachers selected the lesson content and the recording window. I recorded each teacher's sequence of lessons on three consecutive days (e.g., Monday, Tuesday, Wednesday) and video collection occurred over three weeks. During classroom observations, I took field notes that included descriptive information and reflective information. Immediately after each observation, I wrote an analytic memo. Finally, I uploaded videos to a secure password-protected file, and I segmented videos into seven-and-a-half-minute clips to prepare for data analysis.

Document Collection

During each observation, I photographed the following artifacts, when available: instructional anchor charts, student activity pages, and lesson plans. Before instruction started, I photographed instructional anchor charts. Instructional anchor charts provided information about the lesson purpose, learning targets, and potential solution pathways the teacher planned to present. During instruction, I photographed student activity pages and manipulatives used. These documents provided evidence of the number and type of student practice opportunities each student engaged with during the lesson. After the observation ended, I photographed the lesson plans teachers reported using to plan for the observed lessons. I used document collection to triangulate data by comparing teachers' self-reported use of instructional materials (i.e., survey responses) with enacted use of instructional materials (i.e., observation field notes). I also used document collection to understand how teacher modifications to instructional materials related to the mathematical quality of instruction observed.

Interviews

Finally, after observations were complete, I interviewed each teacher. The interview occurred using the videoconferencing platform *Zoom*. I used *Zoom's* transcription tool to transcribe the audio portion of each interview. Each teacher selected a 30-minute time slot before or after school. Using the interview protocol (see Appendix B), I conducted a semi-structured interview. To increase trustworthiness, I took reflective notes immediately after the interview to identify personal bias and generate an audit trail (Hatch, 2002).

Data Analysis

To increase the trustworthiness of findings, researchers should use a systematic strategy for scoring and analyzing data (Creswell & Guetterman, 2019). In this section, I describe the data analysis process for each study instrument and discuss how I used qualitative data to expand my understanding of quantitative data.

Survey

Using descriptive statistics, I analyzed survey responses to describe how teachers use instructional materials to plan mathematics instruction. First, I used the codebook provided with the AIRS instrument and I assigned each variable an abbreviated name, descriptive label, and numerical value. The numerical value was used to generate descriptive statistics: mean, standard deviation, and range (Creswell & Guetterman, 2019). Next, I coded all data using the codebook and entered the data in an Excel spreadsheet that is stored in a secure, password-protected file. Last, to enhance validity, I triangulated teacher responses with classroom observation field notes and document collected (Creswell & Creswell, 2018). To protect and maintain confidentiality, I did not report any individual survey responses.

Observations

I analyzed the mathematical quality of instruction using the MQI observation protocol. First, I watched the entire lesson without stopping. Next, I re-watched the lesson in four, seven-and-a-half minute clips. I stopped after each seven-and-a-half-minute clip and coded 21 segment codes using the observation protocol. I continued until all four clips were coded. After coding each video segment, I coded the ten whole lesson codes using the observation protocol. To finish analysis, I repeated this process for each video. I recorded the data in an Excel spreadsheet, stored it in a secure, password-protected file. I reported data using descriptive statistics: mean, standard deviation, and range (Creswell & Creswell, 2018). To protect confidentiality, I reported MQI scores at the aggregate level (i.e., kindergarten observations, second grade observations, and all observations).

Also, I took several steps to improve the reliability of the findings. First, I completed the 16-hour coder training developed by the LMTP (2014). This helped ensure I coded reliably (Hill et al., 2012). Along with certification, it is important to have specific subject-area knowledge. My qualifications include experience teaching mathematics in first, second, and fourth grade, and a Mid-Level Mathematics Teaching Certificate. Finally, a second coder completed the same online training and double coded 15% of the observation videos. The second coder has experience teaching elementary mathematics and has served as a mathematics coach. To evaluate inter-rater reliability, I randomly selected three videos for the second coder to analyze using the MQI observation protocol. After she completed coding, I compared all segment codes and whole lesson codes to evaluate for exact match agreement. There was 92% exact match agreement for segment codes and 90% exact match score agreement for whole lesson codes.

Interviews

To analyze interview data, I followed several analytic procedures, which include writing analytic memos, developing a codebook, coding data to identifying themes and patterns, revising the codebook, and writing a rich, descriptive narrative. Given that qualitative data analysis begins during data collection (Patton, 2015), I started by taking notes during each interview and writing an analytic memo immediately following the interview. In the analytic memo, I noted how the teacher used instructional materials and considered the potential relationships between teacher modifications and mathematical quality of instruction. Writing analytic memos during the data collection phase informed my data analysis process. For example, after interviewing Ms. Foxglove, I noticed that the way she used instructional materials might deteriorate the cognitive demand of the mathematical task presented, as noted in the following memo:

> Ms. Foxglove modified instructional materials to make mathematical content easier for students. She modified instruction materials to address "dryness" of provided materials. During her second lesson, she used food to engage students. Compare observed instruction with collected instructional materials. Her modification might reduce cognitive demand. (November 8, 2022)

This memo prompted me to compare teacher modifications and documents collected to evaluate cognitive demand.

Next, I developed a codebook using *a priori* codes aligned to the research questions, existing literature, and the conceptual framework (see Appendix C; Patton, 2015). First, I created four categories to organize the codes: instructional materials, instructional practices, time utilization, and implementation needs. Next, within each category, I generated individual codes to be specific, but not too narrow, and closely aligned with the research questions (Bazeley, 2013). For example, "conceptual knowledge" is a code within instructional practices. After identifying codes, I defined each code using relevant literature. After drafting the codebook, I engaged in the first round of coding using the *a priori* codes, and I completed analytic memos to note theoretical insights (Patton, 2015).

Following the initial round of coding, I identified emergent codes. For example, after reviewing Ms. Aster's interview transcript, I added the code "multiple representations" to the "instructional practices" category. This was in response to an analytic memo made following the first round of coding noted below:

> Ms. Aster modified for instructional materials for engagement and to make them more kindergarten friendly. She uses curriculum with limited fidelity. This might be because she does not have access to entire curriculum. She reported combining lessons to increase

> rigor, but when comparing with documents, this reduced rigor. The curriculum suggested using multiple representations of eight. Curriculum improved instruction. (December 31, 2022)

While coding, I noticed several teachers were using multiple representations as an instructional practice. This is a feature of instruction measured by the MQI and I wanted to better understand if instructional materials influenced teachers' use of multiple representations, so I added the "multiple representation" code to my codebook. Using both *a priori* codes and emergent codes provided the opportunity to align my codes to the research questions and conceptual framework, while also addressing new insights in the data.

Finally, I strategically and systematically interpreted the data moving through four phases: patterns, synthesizing, frequencies, and comparisons (Bazeley, 2013). First, I explored potential patterns and relationships in the codes. I recorded all the patterns in my reflection log to generate an audit trail. For example, I noticed that all kindergarten teachers used the district scope and sequence to determine the order they would teach mathematical concepts, but none of the kindergarten teachers used the district-provided curriculum (i.e., *enVisionMath*) with high fidelity (i.e., few or no modifications to the provided lesson plan). Next, I synthesized my ideas by listing all the big ideas that emerged from the data.

- Teachers use instructional materials in different ways.
- Teachers believe they modify instructional materials to increase rigor, but often the modifications actually reduce rigor.
- Teachers eliminate or modify high-cognitive demand mathematical tasks provided in instructional materials.

- Second grade teachers use curriculum-provided student practice pages and kindergarten teachers use self-selected student practice pages.

Using this list, I used response frequencies to confirm my initial interpretations. To find comparisons, I color coded the data segments to visually see different ideas that emerged. For example, I colored all data segments about reducing rigor blue and all data segments about increasing rigor green. Throughout the process, I created an audit trail using a reflective log and analytic memos to reflect my decision-making process and to address my researcher positionality. After I drafted initial findings, I engaged in peer review to receive constructive feedback and challenge my thinking. Using the feedback from this process, I finalized the interview findings.

Documents

I simultaneously conducted document analysis with observation and interview data analysis. This provided an opportunity to triangulate data across observation field notes, MQI scores, interview response, and collected documents (Merriam & Tisdell, 2015). I used the following analytic procedures to complete document analysis. First, I determined which materials to collect (i.e., anchor charts, student practice pages, and lesson plans). Next, I photographed these documents during classroom observations. Once photographed, I uploaded the photographs to a secure, password-protected file, I closely read each document, and I drafted an analytic memo. I wrote the analytic memo to capture the initial differences between enacted instruction and suggested instruction. For example:

> Ms. Dodder's anchor charts used word problems provided by *enVisionMath*. She followed the sequence of instruction suggested in the Interactive Problem-Based Learning Activity. Student practice pages were from *enVisionMath*. (October 4, 2022)

This information prompted me to ask individual teachers, during one-on-one interviews, to identify which components of *enVisionMath* they reference to plan mathematics. By adding this to my initial interview protocol, I was able to better understand how teachers used individual components of the district-provided curriculum.

After initial document analysis, I completed comparative analysis to understand the relationship between instructional materials and the quality of observed instruction. Comparative analysis furthers analysis by providing a more comprehensive picture of the problem of practice (Bazeley, 2013). To complete my second round of document analysis, I compared:

- Lesson plan provided objectives and teacher enacted objectives
- Lesson plan provided word problems and teacher enacted word problems (if applicable)
- Curriculum-provided student practice pages with teacher-selected student practice pages
- Second grade student practice pages with kindergarten student practice pages

For example, to compare word problems, I created a table to that included the lesson plan provided word problem alongside the observed, enacted word problem (if applicable). Ms. Coriander's lesson plan included the following word problem: "Snappy Crab sees 6 seashells. How can he show how many seashells he sees?" Observation data revealed that she did not use any word problems. Throughout the process, I maintained a reflective log to generate an audit trail (Merriam & Tisdell, 2015).

Ethical Considerations

When conducting research, it is important to evaluate and address ethical issues. Patton (2015) provides a checklist for researchers to use when considering ethical issues, which includes an assessment of benefits and risks to participants, informed consent, confidentiality, and data security. I used this checklist to minimize ethical issues during the study.

During the design of the study, I evaluated potential benefits and risks for participating teachers and the key stakeholders. I provided reciprocal benefits to both stakeholder groups. First, I designed the study to provide district administration with actionable recommendations. I worked closely with the building principal and director of curriculum and instruction to develop research questions that provided the most beneficial information. Second, after analyzing classroom observation videos, I provided individual teachers with targeted feedback to improve their mathematics instruction. Additionally, I incorporated teacher perspectives into the recommendations to ensure the feasibility of recommendation implementation for teachers.

I followed IRB-SBS procedures for informed consent, confidentiality, and data security. I asked for informed consent before teachers completed the survey, participated in video observations, and completed interviews. Additionally, I continually reminded teachers they can withdraw from the study at any point. To maintain confidentiality, I assigned all teachers a pseudonym, I presented quantitative data the aggregate level (grade level or all observations), and I did not use any quotes that might identify individual teachers. Following IRB-SBS procedures for data security, I stored data in a secure, password protected location. Only researchers included on the IRB protocol have access to the data. Finally, all data was de-identified and given a study ID. I stored the study ID numbers linked with teacher names in a password-protected file.

Role as a Researcher

Several personal experiences influenced my role as a researcher, my experience as a former classroom teacher, and my personal relationship with the participants. As a former classroom teacher at Hillside Elementary School, I have taught first, second, and fourth grade. While serving in this role, I used *enVisionMath*, the district-provided curriculum, to plan for mathematics instruction. Also, I served as a member of the mathematics team who developed the district-level scope and sequence for mathematics. Additionally, I have had a positive experience with mathematics as a student and as a teacher. I'm invested in providing mathematics instruction using the district-identified resource because I strongly believe that using standards-aligned curricula improves the quality of mathematics instruction. My subject-specific skills and beliefs about mathematics informed the interpretation of findings.

Second, I have a personal relationship with all the participants. Because I am a former colleague, teachers felt comfortable recording "business-as-usual" mathematics instruction and honestly responding to interview questions. As a result, I gained deeper insights into the problem of practice and teachers openly shared their perspectives. Last, teachers felt safe expressing mathematical beliefs that did not align with my beliefs. During data collection and analysis, I strived to suspend my bias keeping a reflective log and I carefully maintained participant confidentiality (Merriam & Tisdell, 2015).

Trustworthiness

I took several steps to enhance the trustworthiness of the study findings. Following Creswell and Creswell's (2018) recommendations, I selected multiple validity procedures to access the accuracy of my findings, which included triangulating data, developing a rich, thick description, member checking, and peer debriefing.

Triangulation. I used two types of triangulation in my study: multiple methods of data collection and multiple sources of data (Merriam & Tisdell, 2015). For multiple methods of data collection, I collected survey responses, observation videos, interview responses, and documents. Using multiple methods of data collection allowed me to analyze how teachers use instructional materials and the quality of mathematical instruction across multiple sources to develop a more comprehensive understanding of the problem of practice. Second, I collected multiple sources of data because I observed each teacher multiple times. This allowed me to cross-check observation data and develop a more accurate picture of the mathematical quality of instruction.

Rich, Thick Description. Next, I presented findings using a rich, thick description by integrating all data sources and providing specific and illustrative examples. As part of data integration, I analyzed discrepant information between data sources and added this information to the description. By providing specific and illustrative examples throughout the narrative, I provided readers with enough detail to develop a deeper understanding of the setting and consider the transferability of the findings to other contexts.

Member Checking. After initial data analysis, I met with key stakeholders (i.e., classroom teachers and district leadership) to ask if my findings accurately reflected their experiences (Creswell & Plano Clark, 2007). First, I met with classroom teachers to review their scores from the MQI observation protocol. Based on the feedback, all teachers agreed with their scores on the MQI. Next, I presented my initial findings to teachers to see if this reflected their own experiences. Finally, I presented the initial findings to the district leadership. I found no disconfirming evidence.

Peer debriefing. Finally, I completed peer debriefing with the identified second-coder for the MQI observation protocol. First, she reviewed my initial findings and drafted a list of questions. Next, we met to discuss her questions and consider strategies for adding clarity to the findings. Finally, I revised my description to add further detail to add clarity to the narrative and improve consistent interpretation of the findings (Creswell & Creswell, 2018).

Limitations

There are several limitations to this study. First, as an internal evaluator, I balanced maintaining a positive relationship with my colleagues and scoring observations accurately with the MQI. The competing goals (i.e., maintaining a positive relationship and scoring accurately) could have created inflated observation scores. In order to address this limitation, I used the services of a second coder, an external researcher who coded 15% of the video recordings for agreement.

Second, the volunteer sample did not include first grade teachers (Sharma, 2014). Researchers have found that teachers interact with curricular materials differently (Hill & Charalambous, 2012b; Remillard, 2005). It is possible that teachers not identified in my sampling strategy would provide a different level of instructional quality as compared to the selected sample. I situated the findings within this limitation, and I reviewed the limitation with the building principal and director of curriculum and instruction at the study site (Mertens & Wilson, 2019).

Third, the small sample size ($n = 6$) for this study suggests its generalization is limited (Mertens & Wilson, 2019). This mixed-method capstone was situated in the pragmatic paradigm, within a small, rural elementary school and designed to be context and time specific and based on the needs of the key stakeholders. In the findings, I included rich, descriptive details in order to allow others to judge the transferability of the findings to other contexts (e.g. the other elementary school within the district).

Chapter 4: Findings

This Capstone was designed to describe the instructional materials teachers used to plan for mathematics instruction and the quality of mathematics instruction. Specifically, the following questions guided the research: 1) What instructional materials do K-2 teachers report using to plan mathematics instruction at Hillside Elementary School? 2) What is the observed quality of mathematics instruction in K-2 classrooms at Hillside Elementary School? and 3) What is the relationship between observed mathematics instructional quality and the instructional materials K-2 teachers used to plan mathematics instruction at Hillside Elementary School? The findings presented in this chapter will inform future curricular initiatives and PLO at Hillside Elementary School.

As outlined in chapter one, this study used a conceptual framework based on a modified version of the Reconceptualized Framework for Opportunity to Learn developed by Walkowiak and colleagues (2017). The modified framework highlights the following dimensions that evidence suggests influences students' opportunities to learn mathematics: School Context, Instructional Materials, Mathematical Tasks, Mathematical Talk, and Time Utilization. The school context includes district policies, school administration, resources, and more that influence the selection of instructional materials and implementation of instruction (Cohen et al., 2003). Instructional materials are the materials teachers use that "serve as daily guides" for planning and enacting instruction (Trafton et al., 2001, p. 259). Mathematical tasks consider the content and execution of instruction. Mathematical talk is characterized by teacher and student talk that is used to move learning forward by deepening student understanding. Finally, time utilization highlights the instructional time focused on mathematical tasks and mathematical talk. These dimensions guided the data analysis process and informed the presentation of the findings.

To explore the research questions, I analyzed quantitative data from surveys and classroom observations and integrated this data with qualitative data from document analysis, observation field notes, and interview responses. This descriptive study design was used to describe the instructional materials teachers used to enact mathematics instruction, the observed quality of mathematics instruction, and the relationship between teachers' use of instructional materials and observed quality of mathematics instruction. As a result, the data demonstrated important findings that answer each research question. In this chapter, I present the following findings:

- Finding 1: Most teachers report using the district-provided curriculum (i.e., *enVisionMath)* as their main mathematics materials, though some teachers supplemented heavily with other instructional materials.
    - Sub-Finding 1.1: Most teachers modified instructional materials to some degree.
    - Sub-Finding 1.2: Teachers believe the district requires them to use the district-provided instructional materials.
- Finding 2: The observed features of mathematical quality ranged from *Not Present* to *Mid-level* quality.
    - Sub-Finding 2.1: Mathematics instruction was consistently error-free and clear.
    - Sub-Finding 2.2: Most instructional segments included classroom work connected to mathematics.
    - Sub-Finding 2.3: Students did not consistently communicate about mathematics.
    - Sub-Finding 2.4: Most mathematical tasks were low cognitive demand.
- Finding 3: The relationship between observed mathematical quality of instruction and teachers' use of instructional materials varied grade level to grade level.

- Sub-Finding 3.1: Second grade instruction included contextualized word problems. Kindergarten instruction did not include contextualized word problems.
- Sub-Finding 3.2: Second grade lessons were more mathematically dense than kindergarten lessons.

Finding 1: Most teachers report using the district-provided curriculum (i.e., *enVisionMath)* as their main mathematics instructional material, though some teachers supplemented heavily with other instructional materials.

Information gathered from the survey, classroom observations, document analysis, and interviews suggested that most teachers use the district-provided curriculum, *enVisionMath*, to some degree. However, some teachers heavily supplemented this curriculum with materials from online sites such as *TPT* and *Pinterest*. Based on the survey results, question one revealed that five teachers (83.3%) reported using *enVisionMath* curricula regularly (once a week or more) and one teacher (16.7%) reported using a teacher-created curriculum, *Guiding Kinders* (Jump & Willis, n.d.), which was purchased from *TPT* (see Table 4.1). Subsequent analysis of classroom observation data, documents, and interview responses seemed to confirm this.

During document collection, five teachers provided me with a copy of the lesson plan from the *enVisionMath* curriculum. The lesson plan provided in the *enVisionMath* curriculum includes the following components: *Lesson Overview*, *Daily Common Core Review*, *Problem-Based Interactive Learning, Guided and Independent Practice Workbook* pages, *Differentiated Instruction* activities, *Leveled Homework* practice pages (i.e., reteaching, practice, and enrichment), and a *Quick Check* assessment (see Appendix D). However, during classroom observations, each teacher implemented different components of the lesson plan. Five teachers used the *Lesson Overview* to determine the objective for the lesson. Three teachers used the

Problem-Based Interactive Learning activity and *Guided and Independent Practice Workbook* pages. Three teachers used the *Leveled Homework* practice pages. One teacher used the *Quick Check* assessment. I did not observe teachers using the *Daily Common Core Review* or *Differentiated Instruction* activities.

Table 4.1

AIRS Results: Questions 1-3

Survey Item	*n*	%
Q1: Which of the following mathematics curricula do you use regularly (once a week or more) for your mathematics instruction?		
District-provided: enVisionMath Common Core, Realize Edition © 2105	5	83.3%
Other: *Guiding Kinders (TPT)*	1	16.7%
Q2: Of the mathematics curricula, you indicated using regularly, please indicate which are provided by your district or school, either as a requirement or recommendation.		
Required by my district or school	5	83.3%
Recommended by my district or school	0	0.0%
Neither required nor recommended by my district or school	1	16.7%
Q3: Please complete the following sentence. I typically use lesson plans from my main mathematics material…		
...with no or few modifications	4	66.7%
...with modifications to less than half of a lesson plan	2	33.3%
…with modifications to more than half of a lesson plan	0	0.0%

Observation and interview data illustrated the degree to which teachers used the different components of the lesson plan provided in the *enVisionMath* curriculum. Implementation of these components ranged from using one feature to using five features. I present evidence starting with the teacher who used the fewest number of features and ending with the teacher who used most of the features provided in the lesson plan.

Ms. Aster reported using *enVisionMath* as her main mathematics resource, but data suggests she used the fewest number of features outlined in the provided lesson plans. During the interview, she shared, "I use *enVisions*, particularly when I'm planning to see what topics we're covering, and what order we're going in. Sometimes I use the worksheet component. There's a book, and I can make a copy from that." (interview, November 2, 2022). During observations, Ms. Aster used the objective from the lesson plan, and during one out of three lessons, she used a *Leveled Homework* reteaching worksheet for the independent practice page. Ms. Aster supplemented two of her lessons with student practice pages found on the internet.

Similarly, Ms. Coriander used few components of the lesson plan from the *enVisionMath* curriculum. She said, "I use *enVisions* really as a resource for the concepts that need to be taught. I use the workbook pages about every other day, but I don't use workbook pages every single day." (interview, November 10, 2022). Ms. Coriander used the lesson plan to identify the concepts she would teach and the order she would teach the concepts. In the first and third observed lessons, she used the practice and enrichment *Leveled Homework* pages. I did not observe her using any other components of the lesson plan. Ms. Coriander supplemented her lessons with self-authored material and *TPT* resources. For example, in lesson two, students rotated among four mathematics learning stations. Three stations comprised instructional materials purchased from *TPT*, and one station included instructional materials created by Ms. Coriander. Finally, she supplemented instructional activities with Jack Hartmann, a children's singer and songwriter on *YouTube*.

Next, Ms. Foxglove used some components of the lesson plan from the *enVisionMath* curriculum. During her interview, she stated:

> I use the student workbook. For those particular lessons, I think I used mostly the student workbook from of *enVisions*. I don't think I used a lot of the other resources for those particular lessons… I will sometimes use the reteaching pages and the practice pages that

> come with it… I use the workbooks, and then with arrays [observed lesson] I supplement because it is a really short unit. (interview, November 8, 2022)

Classroom observations confirmed that Ms. Foxglove used the student *Guided and Independent Practice Workbook* pages. I did not observe her using the *Leveled Homework* pages (i.e., reteaching and practice pages) during the three lessons that were part of this study. Her interview response suggests that she might use more elements of the curriculum than observed. Ms. Foxglove supplemented two lessons with teacher-created games (e.g., scoot) and a number cube game. Also, she adapted the *Quick Check* provided in the *enVisionMath* lesson plan by taking screenshots of individual problems and creating a *Seesaw* activity. Mrs. Foxglove completed the first two problems with students and asked students to complete the last problem on their own.

Conversely, the remaining two teachers used numerous components of the lesson plan in the *enVisionMath* curriculum. Ms. Hollyhock likes to read through the entire topic, or unit, before focusing on individual lesson plans. Ms. Hollyhock does this to understand the sequence of instruction and how each lesson builds towards mastery of the topic standards. She said, "I take out each topic [teacher manual], and I will read through it before I teach that lesson just as a little refresher." (interview, November 3, 2022). Additionally, she reported that she uses the *Problem-Based Interactive Learning* introduction activity stating, "I like that section [*Problem-Based Interactive Learning* activity] specifically because I feel it's very directed instruction." (interview, November 3, 2022). However, she also states that she supplements her lessons by sharing, "I have gathered over the years of using this program, a ton of stuff from *TPT"* (interview, November 3, 2022). During the observations, Ms. Hollyhock used the *Problem-Based Interactive Learning* introduction activity, and she used the *Guided and Independent Workbook* practice pages. She supplemented lesson two with a self-authored digital enrichment activity on *Seesaw* and she supplemented lesson three with a teacher-created number cube game where students rolled number cubes to generate and compare two-digit numbers.

Ms. Dodder used the most components of the lesson plan in the *enVisionMath* curriculum and did not supplement the materials. Ms. Dodder said:

> I just use the Teachers manual… whether it's the objective or the target, I kind of follow through what the key points are, or what I'm supposed to teach that day. And [I] look at the examples [activities], and then that helps me create an anchor chart. You know what word problems I might use, or scenarios or examples. So, I kind of just take what they give me, the examples and [that] kind of just drives my instruction through their examples. (interview, November 1, 2022)

In all three lessons, I observed her using the *Lesson Overview*, *Problem-Based Interactive Learning* activity, *Guided and Independent Workbook* practice pages, and *Leveled Homework* reteaching and enrichment pages. Ms. Dodder did not use supplemental material during the three observed lessons.

Finally, the sixth teacher, Ms. Bellflower, elected to use a curriculum purchased from *TPT*. This curriculum, *Guiding Kinders* by Deanna Jump and DeeDee Willis, includes the following components: *Fluency, New Concept, Whole Group Explore, Student Application, Regroup and Share, Videos for this Concept, Vocabulary,* and *Literacy Connection* (see Appendix E). Ms. Bellflower reported, "I pretty much follow exactly what she [DeeDee Willis] says, and you know the materials that she recommends." (interview, November 1, 2022). During observations, she used most of the components, including *Fluency, New Concept, Whole Group Explore,* and *Student Application*. In lesson two, she used the *Literacy Connection*, but she reported she does not do this during every lesson stating, "I don't do it with every lesson, but I try to do it at least once a week…a lot of the times it's the same book as the next lesson." (interview, November 1, 2022). During the observed lessons, she did not use any part of *enVisionMath*. Finally, Ms. Bellflower did not use supplemental material during the three observed lessons.

In the following sub-sections for Finding 1, I describe the ways teachers modified instructional materials and their reported beliefs about district implementation policies.

Sub-Finding 1.1: Most teachers modified lesson plans provided by instructional materials to some degree.

In the previous section, data illustrated the different components teachers used from the lesson plans included in their main mathematics instructional material. Most teachers also modified the provided lesson plans by heavily supplementing and/or adapting the identified material. Survey results highlighted that four teachers (66.7%) reported using the lesson plan provided by their identified curricula (e.g., *enVisionMath*) with few or no modifications (see Table 1).

The remaining two teachers (33.3%) reported having modified their curriculum lesson plans less than half of the time. However, results from the observation and document analysis data suggest something different. Based on these data, two teachers use provided lesson plans with no or few modifications, two teachers modified provided lesson plans less than half of the time, and two teachers modified provided lesson plans more than half of the time. In this section, I provide examples of how individual teachers modified the lesson plan from their identified curricula, starting with the teachers who made the least modifications and ending with the teachers who made the most modifications.

Ms. Dodder and Ms. Bellflower made few modifications to the lesson plan provided in their curricula (i.e., *enVisionMath* and *Guiding Kinders*). As previously mentioned, both teachers used the most components of the lesson plan provided in their curricula and did not use supplemental materials. Both teachers made few modifications. For example, Ms. Dodder used the *Leveled Homework* reteaching page to provide interventions instead of the *Differentiated Instruction* intervention lesson to support students who struggled. Similarly, Ms. Bellflower used Math Stackers in place of connecting cubes to model ways to make ten, compare numbers 1-5, and compare numbers 6-8. Math Stackers are foam blocks that are different sizes to represent the numbers 1-10.

Ms. Foxglove and Ms. Hollyhock made modifications to less than half the lesson plan. Ms. Foxglove modified the *Problem-Based Interactive Learning* section of the lesson plan. She selected her own word problems and changed the recommended delivery of instruction. For example, in lesson one, the provided word problem was "Four people go on a hike together. Each of them brings 3 oranges. How can you find how many oranges the hikers have in all?" and Ms. Foxglove replaced this word problem with "I have 3 jars. In each jar, I put 4 marbles. How many marbles do I have in all?" Additionally, Ms. Foxglove overly scaffolded the word problem by providing a representation with three jars holding four marbles. The lesson plan suggested students use counters to create their own representation, followed by the teacher modeling four groups of three.

Ms. Hollyhock also modified the *Problem-Based Interactive Learning* section and the recommended delivery of instruction. For example, in the first observed lesson, the lesson plan provided problem was, "How can you use the connecting cubes to show 23 in more than one way?" Ms. Hollyhock modified this by asking groups of students to solve this question, but she changed the number for each group. She elected not to use connecting cubes and instead provided different Halloween themed objects (e.g., candy corn, sour candy, and Halloween pencils) for students to represent their respective numbers.

Ms. Aster and Ms. Coriander made modifications to more than half of the lesson plan for all observed lessons. As stated earlier, neither used many components of *enVisionMath* curriculum, therefore, they modified all components of the lesson plan other than the lesson objective. Ms. Aster developed her own introduction activities and found supplemental materials for student practice. In addition, Ms. Aster combined two lesson plans together for each observed lesson. For example, during the first observed lesson she combined “Counting 6 and 7” with “Reading and Writing 6 and 7.” During the interview she stated, “Sometimes, when I'm planning, I will combine some lessons together just based off of where my kids are.” (interview, November 2, 2022).

Comparably, Ms. Coriander also modified all components of the lesson plan, other than the lesson objective. She created her own introduction activities and found supplemental materials for student practice. She also modified the instructional sequence provided in the curriculum. For example, the provided curriculum included a lesson titled “Counting 8 and 9” and “Reading and Writing 8 and 9.” Ms. Coriander adjusted her instruction to teach individual numbers (i.e., Counting, Reading, and Writing 8 and Counting, Reading, and Writing 9). Her selected instructional activities reflected this change because during the second observed lesson she showed Jack Hartmann’s *YouTube* video “I Can Show the Number 8 in Many Ways” and during the third observed lesson she showed Jack Hartmann’s YouTube video “I Can Show the Number 9 in Many Ways.”

Sub-Finding 1.2 Teachers believe the district requires them to use district-provided instructional materials.

Building on this, five teachers (83.3%) reported that they used the *enVisionMath* curriculum because it was required by the school district (see Table 1). Mrs. Bellflower also acknowledged that she believed the district required teachers to use *enVisionMath*, but she has decided not to do this because she did not think it was meeting the needs of her students. During her interview she stated, “I'm not going to follow the district rules, and I need to find something that’s better.” and “I need to find what’s best for my students.” (interview, November 1, 2022). Based on these responses, teachers believe there is a district policy about curriculum implementation, despite the fact that the school district does not have an implementation policy specific to *enVisionMath*.

This is further illustrated with survey responses related to the digital materials teachers use. Teachers reported using three additional digital resources to support mathematics instruction: *IXL* (i.e., “I excel”), *ST Math*, and *XtraMath* (see Table 4.2). *IXL* is an online, interactive learning platform that provides student activities based on inputted data or teacher selection. *ST Math* is an interactive problem-solving game aligned with grade-level mathematics standards. *XtraMath* is an online website that provides basic math fact practice through timed quizzes. For this study, I only reported district-provided digital resources in the results. Participants identified additional free resources (e.g., *Kahoot*, *YouTube*, and *Zearn*), but there were no consistent patterns of use across all six participants. Furthermore, teachers identified using these resources less frequently than the district-provided digital resources.

Table 4.2

AIRS Results: Questions 4-5

Survey Item	*n*	%
Q4: Please indicate which digital materials your students and/or you use regularly (once a week or more) for mathematics instruction.		
IXL	5	83.3%
Xtra Math	4	66.7%
ST Math	2	33.3%
Q5: Of the digital materials, you indicated using regularly, please indicate which are provided by your district or school, either as a requirement or recommendation.		
Required by my district or school		
IXL	5	83.3%
XtraMath	0	0.0%
ST Math	1	16.7%
Recommended by my district or school but not required		
IXL	0	0.0%
XtraMath	3	50.0%
ST Math	1	16.7%
Neither Required or recommended by my district or school		
IXL	0	0.0%
XtraMath	1	16.7%
ST MATH	0	0.0%

Based on survey question five, five teachers (83.3%) believe that *IXL* is required to use by the school district and one teacher (16.7%) believes *ST Math* is required by the school district. Three teachers (50%) believe the school district recommends *XtraMath* and one teacher (16.7%) believes the school district recommends *ST Math*. In 2021-2022 school year, the school district purchased *IXL* and *XtraMath Premium* as optional resources to use for additional practice and differentiation. These resources are not required or recommended. In previous years, the district purchased *ST Math*, and it was a recommended resource. However, in the 2022-2023, the district discontinued its subscription. This data suggests teachers believe there are district policies on the use of provided digital materials, even though this is not true.

Finding 2: The observed features of mathematical quality varied from *not present* to *mid-level* quality.

Information collected from three video-recorded observations, document analysis, and interviews suggested that the quality of mathematics instruction varied from *Not Present* to *Mid-level* quality. The MQI was used to quantify the features of mathematics instruction. This systematic observation tool comprises of 21 segment level codes. I rated segment level codes on a scale of one to four. A rating of one means the mathematical feature is *not present*. I coded each 30-minute video in seven-and-a-half minute segments for a total of 12 segment level codes per teacher. Table 4.3 illustrates the mean, range, standard deviation, and quality score for the overall segment level codes. I triangulated the data using document analysis and interview responses. First, I share the data that illustrates mixed-level quality. Next, I present the results for two sub-sections organized by strengths across all observations and weaknesses across all observations.

Table 4.3

MQI Overall Segment Codes

Segment Code	*n*	*M* (SD)	Range	Quality
Overall Richness of Mathematics				
All Observations	6	2.58 *(0.10)*	1-4	Mid
Kindergarten Observations	3	2.16 *(0.14)*	1-4	Low
Second Grade Observations	3	3.00 (0.09)	2-4	Mid
Overall Working with Students and Mathematics				
All Observations	6	2.49 *(0.08)*	1-4	Low
Kindergarten Observations	3	2.16 *(0.12)*	1-3	Low
Second Grade Observations	3	2.80 *(0.08)*	2-4	Mid
Overall Errors and Imprecision				
All Observations	6	1.08 *(0.03)*	1-2	Not Present
Kindergarten Observations	3	1.14 *(0.06)*	1-2	Not Present
Second Grade Observations	3	1.03 *(0.03)*	1-2	Not Present
Overall Common Core Aligned Student Practices				
All Observations	6	2.22 *(0.10)*	1-4	Low
Kindergarten Observations	3	1.86 *(0.14)*	1-4	Low
Second Grade Observations	3	2.58 *(0.12)*	1-4	Mid

Note. I did not do any formal hypothesis testing given the small sample size.

Mixed Level-Quality

The resultant data in Table 4.3 illustrates the mixed-level quality across all overall segment codes. I did not consistently observe high quality mathematical features between grade-levels for two overall segment codes: *Overall Richness of Mathematics* and *Overall Working with Students and Mathematics*. For all observations, *Overall Richness of Mathematics* scored *mid*, with a mean score of 2.58 (SD = 0.10) and *Overall Working with Students and Mathematics* scored *low*, with a mean score of 2.49 (SD = 0.08). *Overall Richness of Mathematics* measures the degree to which elements of rich mathematics (i.e., linking between representations, explanations, mathematical sense-making, multiple solution methods, patterns and generalizations, and mathematical language) are present during the segment. *Overall Working with Students and Mathematics* measures the overall teacher-student interactions related to the mathematical content (i.e., remediation of student errors and difficulties and teacher use of student contributions) (see Appendix G). Within these two segment codes, there is systematic variation in observed quality based on grade level[2]. For *Overall Richness of Mathematics*, Kindergarten observations scored *low*, with a mean of 2.16 (SD = 0.14) while second grade observations scored *mid*, with a mean of 3.00 (SD = 0.9). Likewise, for *Overall Working with Students and Mathematics*, kindergarten observations scored *low*, with a mean of 2.16 (SD = 0.12) whereas second grade observations scored *mid*, with a mean of 2.80 (SD = 0.08). However, across the segment codes within these dimensions, all kindergarten observations did not consistently score *low*, *mid*, or *high* on specific features of mathematics. Similarly, all second grade observations did not consistently score *low*, *mid*, or *high* on specific features of mathematics. Therefore, data suggests individual teachers demonstrate strengths and weaknesses

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[2] I did not complete formal hypothesis testing given the small sample size.

within the *Richness of Mathematics* and *Working with Students and Mathematics* dimensions. To protect teacher confidentiality, I cannot present individual teacher scores to illustrate individual teacher strengths and weaknesses within these dimensions.

Strengths Across All Observations

Based on my read of the data, there were two strengths across all observations. In this section, I elaborate on Sub-Finding 2.1 and Sub-Finding 2.2.

Sub-Finding 2.1: Teachers are consistently providing error-free, clear mathematics instruction. *Overall Errors and Imprecision* was a strength across all observation segments with a mean score of 1.08 (SD = 0.03). A score of one means the mathematical feature was *Not Present* during the segment. I did not consistently observe teachers making mathematics errors, using imprecise language and notation, or presenting content unclearly. However, based on document analysis and field notes, most observed instruction and identified lesson objectives focused on building procedural knowledge and skills (see Table 4.4). Therefore, it is unclear the degree to which teachers could be mathematically precise or error-free in more conceptually oriented lessons.

Table 4.4

Document Analysis: Lesson Objectives

Teacher	Observation 1 *Lesson Objective*	Observation 2 *Lesson Objective*	Observation 3 *Lesson Objective*
Ms. Aster	Children will use objects to represent and count the quantities of 6 and 7 and understand that the last number said tells the number of objects counted. Children will recognize and write the numerals that describe quantities 6 and 7.	Children will use objects to represent and count the quantities of 8 and 9 and understand that the last number said tells the number of objects counted. Children will recognize and write the numerals that describe quantities 8 and 9.	Children will use objects to represent and count the quantity of 10 and understand that the last number said tells the number of objects counted. Children will recognize and write the numerals that describe the quantity 10.
Ms. Bellflower	**Composing and Decomposing Numbers**	Ordering objects to 5	Ordering objects to 10
Ms. Coriander	Children will recognize and write the numerals that describe quantities 6 and 7.	Children will recognize and write the numerals that describe the quantity 8.	Children will recognize and write the numerals that describe the quantity 9.
Ms. Dodder	Children will use counters to model and solve addition and subtraction problems.	Children will solve two-question problems by using the answer to the first question to answer the second question.	Children will model repeated addition to write number sentences.
Ms. Foxglove	Children will model repeated addition to write number sentences.	Children will build arrays to model repeated addition situations	Children will use repeated addition to solve problems.
Ms. Hollyhock	**Children will group objects into tens and ones to show two-digit numbers.**	Children will read and write numbers for numbers 0-99.	Children will compare two-digit numbers using symbols.

Note. Objectives are bolded if the observed instruction focused on developing conceptual knowledge.

Sub-Finding 2.2: Most instructional segments include classroom work connected to mathematics. Second, teachers connected classroom work to mathematics 90.2 percent of the observed instructional time (see Table 4.5). The dichotomous segment code, *Classroom Work is Connected to Mathematics,* focused on measuring if more than half of the segment (3.75 minutes or more) is classroom work connected to mathematics. For example, an observational segment scored yes if observed instruction included reviewing or introducing a mathematical concept for 3.75 minutes or more. An observational segment scored no if observed instruction included distributing materials or students are doing work (cutting, pasting, coloring) that is not connected to the mathematical concept for 3.75 minutes or more. The observed classroom work focused on mathematics 83.3 percent in kindergarten classrooms. The observed classroom work focused on mathematics 97.25 percent in second grade classrooms.

Table 4.5

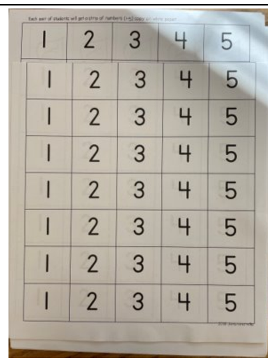
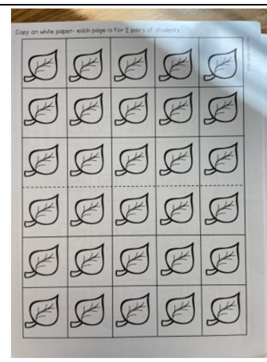
MQI Segment Code: Classroom Work is Connected to Mathematics

Segment Code	*n*	Yes	No	%
Classroom Work is Connected to Mathematics				
All Observations	6	65	7	90.2%
Kindergarten Observations	3	30	6	83.3%
Second Grade Observations	3	35	1	97.2%

Document analysis revealed that instructional materials selected by kindergarten teachers included more activities that were not connected to mathematics, like cutting, pasting, coloring. Ms. Bellflower's instructional materials frequently included cutting, pasting, and coloring (see Figure 4.1). During observation two, students spent time cutting out numbers and leaves. While these materials were used to develop a mathematics concept, the time required to cut out these materials took away from instructional time. It is important to note that Ms. Bellflower realized this and adjusted the next observed lesson, by eliminating the cutting and pasting activity recommended in *Guiding Kinders*.

Figure 4.1

Examples of Classroom Work Not Connected to Mathematics

	Instructional Materials		Classroom Activity
Ms. Bellflower Observation 2 Objective: Ordering numbers to 5			Students cut numbers and leaves to build a model. Next, students glued the model to construction paper. 

Comparably, Ms. Coriander's self-selected supplemental materials included one opportunity for students to cut, paste, and color. In observation two, students moved through four stations. Three stations focused on mathematical work. One station focused on creating a craft spider. Students colored the parts of a spider, cut out each individual piece, and glued the different parts of a spider together. This was the only cut-and-paste activity observed.

Finally, in Ms. Aster's first observation, she used candy corn and candy pumpkins to support her lesson objective (i.e., Children will recognize and write the numerals that describe quantities 6 and 7.). After students completed a procedural worksheet, they sat and ate their candy. This was the only lesson I observed students eating snack during mathematics instructional time. I did not observe cutting, pasting, or coloring in second grade classrooms or in second grade instructional materials.

Weaknesses Across All Observations

The results from observation data also suggest weaknesses in the *Common Core Aligned Student Practices* dimension. Across all observations, the *Overall Common Core Aligned Student Practices* segment code scored *low*, with a mean of 2.22 (SD = 0.10). However, when exploring grade-level data, there is mixed-level quality. Kindergarten observations scored low, with a mean of 1.86 (SD = 0.14), while second grade observations scored mid, with a mean of 2.58 (SD = 0.12). When closely analyzing the data, within this dimension, I discovered that two segment level codes scored *low* across both grade levels: *Students Communicate About Mathematics* and *Task Cognitive Demand* (see Table 4.6). There were no consistent patterns for mid-level segment codes across both grade levels. I provide evidence for Sub-Finding 2.3 and 2.4 in the following section. I triangulated the data with observation field notes and document analysis.

Table 4.6

MQI Segment Codes: *Students Communicate About Mathematics and Task Cognitive Demand*

Segment Code	*n*	*M* (SD)	Range	Quality
Students Communicate About Mathematics				
All Observations	6	2.04 *(0.09)*	1-4	Low
Kindergarten Observations	3	1.72 *(0.12)*	1-3	Low
Second Grade Observations	3	2.36 *(0.11)*	1-4	Low
Task Cognitive Demand				
All Observations	6	1.86 *(0.09)*	1-4	Low
Kindergarten Observations	3	1.78 *(0.13)*	1-4	Low
Second Grade Observations	3	1.94 *(0.13)*	1-3	Low

Sub-Finding 2.3: Students did not regularly communicate about mathematics. For all observations**,** *Students Communicate About Mathematics* scored *low,* with a mean of 2.04 (*SD = 0.9*). This was consistent across grade levels. Kindergarten observations scored *low,* with a mean of 1.72 (*SD = 0.12*) and second grade observations scored *low,* with a mean of 2.23 (*SD =*

0.11). Mathematical talk is teacher or student talk helps deepen student understanding of mathematical concepts. This segment level code examined student talk, not teacher talk. A quality score of *low* means student contributions were very brief. For example, they may provide one- or two- word responses to questions (see Appendix H). Later analysis of documents, observation field notes, and interview responses triangulated these results. I provide evidence in the remainder of this section.

Document analysis of the *enVisionMath* curriculum suggested the provided lesson plans prompt teachers to let students' "partner" or "work with a partner" but do not explicitly discuss student mathematical talk. The limited opportunities for student mathematical talk during observed *enVisionMath* lessons seem to be specific to individual teachers. For example, observation field notes provide evidence that Ms. Hollyhock provided an opportunity for mathematical talk during observation one. During this observation, she provided four groups with a number (e.g., 23) and she tasked each group with determining the number of tens and ones (e.g., two tens, three ones). During this activity, I observed students engaging in mathematical discussions about the representation they used to determine the number of tens and ones. Second, Ms. Dodder justified her choice to provide a turn-and-talk opportunity in each observed lesson by saying, "I think it's important that students are explaining to each other their reasonings or rationale. I think it helps different students hear and understand things in a different way, because this person might have a different strategy." (interview, November 1, 2022). When asked if this was prompted by the *enVisionMath* curriculum, she responded, "I don't recall it saying to turn and talk. I think it's just based on, my knowledge." (interview, November 1, 2022).

Alternatively, document analysis of the *Guiding Kinders* curriculum revealed that the provided lesson plans do explicitly prompt teachers to provide opportunities for student mathematical talk. In the first lesson plan, it prompted the teacher to provide students with speech bubbles that say, "___ and ___ make ___." Students used these speech bubbles during the first observation. One student said, "Three and seven make ten." This statement helps students articulate their thinking, but it does not necessarily deepen their understanding of the ways to make ten. Instead, it might be helpful for students to use a sentence frame like, "I know ___ and ___ make ten because…" This would challenge students to justify their reasoning and explain their understanding.

Next, Ms. Bellflower's second lesson plan and classroom observation illustrate another opportunity for students to communicate about mathematics. During this lesson, she gave students a partner. With their partner, they were supposed to ask questions to compare numbers one to five. For example, they might ask, "How many more is four than one?" Although Ms. Bellflower requested students to engage in partner talk, only a few partners asked questions about their model due to the students focusing on cutting and pasting their numbers and leaves. Similarly, the third lesson plan suggested to partner students to ask questions and compare numbers six to ten, but Ms. Bellflower eliminated the cut-and-paste activity which created the model used for mathematical talk. When asked about student opportunities to communicate about mathematics, Ms. Bellflower stated, "I feel like it's important for them to be talking about math because they're going to use math every day." (interview, November 1, 2022). Like Ms. Dodder, Ms. Bellflower believes it is important for her students to talk about mathematics.

Sub-Finding 2.4: Most mathematical tasks were low cognitive demand. Across all observations, *Task Cognitive Demand* scored low with a mean of 1.86 (SD = 0.09). Kindergarten observations scored *low*, with a mean of 1.78 (SD = 0.13) and second grade observations scored *low*, with a mean of 1.94 (SD = 0.13). *Task Cognitive Demand* measures if the mathematical task supports deep reasoning with mathematics. This segment code focuses on how teacher enacts the task, not the initial demand proved in the curriculum. At the high level, a task might provide opportunities for students to develop conceptual understanding of concepts or relationships, make connections between different representations, and/or provide explanations and justifications to responses (see Appendix H).

As noted in Table 4.4, document analysis also revealed that observed lessons focused on developing procedural knowledge. Given this, instructional materials provided limited high cognitive demand tasks. Across most observations, teachers provided clear steps for students to take to execute the lesson activity. For example, Ms. Aster combined objectives for two lesson plans included in *enVisionMath* curriculum. The referenced objectives included: "Children will use objects to represent and count the quantities of 6 and 7 and understand that the last number said tells the number of objects counted" and "Children will recognize and write the numerals that describe quantities 6 and 7." Based on field notes from the observation, the instruction focused on the mastering skills in the objective and not on "understanding that the last number said tells the number of objects counted." The teacher modeled how to count six objects and seven objectives. Students moved to their seats and they counted one group of six objectives and one group of seven objectives. Next, students practiced writing the number six and the number seven.

Alternatively, Ms. Bellflower's referenced objective for observation one stated, "Composing and decomposing numbers." Composing numbers in math is putting two or more parts together to make a whole. Decomposing numbers in math is breaking numbers into two or more parts. Based on the provided lesson plan, the focus of the lesson was composing the number ten using two parts. The language included in the lesson plan suggested the teacher heavily scaffold and provide procedural steps for students to follow. For example, the lesson plan suggests the teacher introduces the concept by saying, "Just like before, I'm going to build combinations of cubes to make ten. If I decide to start with 4 blue [cubes], how many orange [cubes] will I need? I need to remember to count them. Count with me." (Jump & Willis, 2014, section 2). The procedural steps implied in the *Guiding Kinders* lesson plan include: 1) select number cubes, 2) count the cubes, and 3) continue adding cubes until you reach ten.

However, Ms. Bellflower introduced the activity differently, saying, "You have to think of a way to make ten that is different than your partners using only two blocks" (observation, October 12, 2022). After the first activity, Ms. Bellflower adapts the *Guiding Kinders* lesson plan and adds a second activity, asking students to compose ten in another way by stating, "This time, you can make ten using any blocks you want. Let's see if we can make different ways. You can use one block, you can use five blocks" (observation, October 12, 2022). Ms. Bellflower provided an opportunity for students to draw connections between representations of ways to compose ten with two addends and ways to compose ten with more than two addends.

Moreover, observation field notes suggest few teachers enacted cognitively demanding mathematical tasks (see Table 4.4). For example, during observation one, Ms. Coriander introduced how to write the number seven. First, she modeled how to write the number seven. Next, she asked students to trace the number seven in the air. Then, she played a Jack Hartmann video about comparing numbers. During the video, students watched and counted when prompted. Finally, the teacher modeled how to compare two numbers. This enacted task does not provide opportunities for students to reason deeply about mathematics. The lesson focuses on listening to the teacher model and reproducing facts (i.e., how to write seven).

Similarly, Ms. Foxglove's introduction task in observation one focuses on reproducing known facts and listening to the teacher. First, she presented three addition sentences on the board (i.e., 3+3, 2+2+2, and 3+5). Next, she introduced the word 'repeat' with the definition "over and over again." Students chorally repeated the teacher-provided definition. After, the teacher presented each individual addition sentence, and the students answered the problem. Finally, the teacher categorized the three problems as repeated addition or not repeated addition. Again, students did not have the opportunities to reason deeply about mathematics.

Finally, Ms. Dodder provided a brief example of a cognitively demanding activity, but she heavily scaffolded the activity for students. First, she posed the question, "Diego picked four green apples and three red apples. Do you add or subtract to find out how many apples Diego picked?" As the teacher read the problem aloud, she modeled the solution for students. First, she selected four green colored tiles to represent the green apples. Next, she selected three red tiles to represent the three red apples. Finally, she asked students, "Do you add or subtract to solve?" After taking several student responses, the teacher showed them how to solve the problem using the colored tiles. Across all observations, enacted mathematical tasks included characteristics that focused on procedural skills (e.g., reproducing known facts and applying procedures) and/or overly scaffolded tasks with suggestions to solve the tasks. Further, students listened to teacher instruction with limited input.

Finding 3: The relationship between observed mathematical quality of instruction and use of instructional materials varied grade level to grade level.

Evidence from survey data, classroom observations, document analysis, and interview responses suggests that the relationship between observed mathematical quality of instruction and the use of instructional materials varied from grade level to grade level. During analysis, there were notable differences by grade level, which I explore in detail with Sub-Finding 3.1 and Sub-Finding 3.2.

Sub-Finding 3.1: Second grade instruction included contextualized problems. Kindergarten instruction did not include contextualized problems.

Across all observations, *Contextualized Problems* scored *low,* with a mean of 1.58 (SD = 0.10) (see Table 4.7). Kindergarten observations scored *not present,* with a mean of 1.03 (SD = 0.03) and second grade observations scored *low,* with a mean of 2.14 (SD = 0.16). Contextualized problems include word problems, real-world application problems, or problems that generate data to be analyzed (LMTP, 2011). At the high level, the contextualized problem provides students with significant sense-making opportunities to think and reason mathematically about the contextualized problem. For example, students would be responsible for unpacking a word problem to determine the operation to apply and generating a representation to justify their thinking. The student would do most of the cognitive work of solving the problem. At the low level, the teacher heavily scaffolds the contextualized problem by telling students the operation to use and the procedure to execute. At the mid-level, the teacher and students might co-construct the solution path, however, students are engaging in some mathematical reasoning (see Appendix H). Integrating observation data with document analysis suggests that instructional materials guided teachers' use of contextualized problems. Observation field notes suggest teachers provided few opportunities to solve word problems and no opportunities for real-world application or data generation. Integrating these findings with document analysis, I provide a rich description of word problem use and lack of use across observations.

Table 4.7

MQI Segment Code: Contextualized Problems

Segment Code	*n*	*M*	Range	Quality
Contextualized Problems				
All Observations	6	1.58 (0.10)	1-4	Low
Kindergarten Observations	3	1.03 (0.03)	1-2	Not Present
Second Grade Observations	3	2.14 (0.16)	1-4	Low

The *enVisionMath* curriculum consistently provides a contextualized word problem in the *Problem-Based Interactive Learning* activity (see Appendix F). Across fifteen analyzed lesson plans, eleven lesson plans provided a contextualized problem in the form of a word problem (see Table 4.8). However, Ms. Aster and Ms. Coriander did not enact any of the provided word problems. Ms. Dodder enacted three of three provided word problems. Ms. Foxglove modified the provided word problems with her own. She enacted six conceptualized word problems. Ms. Hollyhock's lesson plans did not provide conceptualized word problems. She modified the provided problem in observation one to align with the definition of a contextualized word problem.

Table 4.8

enVisionMath: Contextualized Problems

Teacher	Observation 1	Observation 2	Observation 3
Ms. Aster	Provided: Rex the puppy has many toys to chew. How can we use counters to find out how many toys Rex has? Snappy Crab see 6 seashells. How can he show how many seashells he sees? Enacted: Did not use.	Provided: Lily made some sandwiches for lunch at the beach. How many sandwiches did she make? Peter watched 8 whales swim in the ocean. He draws 8 whales. What other way can he use to show the number of whales he saw? Enacted: Did not use.	Provided: One day Harry the Horseshoe Crab saw some ducks swimming in a pond. How can you find how many ducks Harry saw? Rosie was sitting on the beach. She saw 10 boats in the ocean. Rosie can draw the 10 boats to show how many there are. What other way can she show the number of boats in the ocean? Enacted: Did not use.
Ms. Coriander	Provided: Snappy Crab see 6 seashells. How can he show how many seashells he sees? Enacted: Did not use.	Provided: Lily made some sandwiches for lunch at the beach. How many sandwiches did she make? Enacted: Did not use.	Provided: Peter watched 8 whales swim in the ocean. He draws 8 whales. What other way can he use to show the number of whales he saw? Enacted: Did not use.
Ms. Dodder	Provided: Diego picks 3 apples. Gail picks 4 apples. Do you add or subtract to find how many apples Diego and Gail pick in all? How do you know? Enacted: Same as provided.	Provided: A squirrel had 8 acorns. Then it found 5 more. How many acorns does the squirrel have now? Enacted: Same as provided.	Provided: Four people go on a hike together. Each of them brings 3 oranges. How can you find how many organs the hikers have in all? Enacted: Same as provided.

Ms. Foxglove	Provided: Four people go on a hike together. Each of them brings 3 oranges. How can you find how many oranges the hikers have in all?	Provided: **Show this arrangement of counters [3 rows of 5] on your work mat on page 105. How can you find how many in all?**	Provided: Rich lines up his toy trucks in 4 rows. He places 3 trucks in each row. how many trucks does Rich have in all? Work with a partner to model and write an additional sentence to solve the problem.
	Enacted: I have 3 jars. In each jar, I put 4 marbles. How many marbles do I have in all? I have 2 gardens. Each garden has 5 flowers. How many flowers are there in all? I have 4 ponds. Each pond has 3 fish. How many fish are there in all?	Enacted: Teacher drew an array on chart paper that shows 3 rows of 4. Teacher asks students to help her write a repeated addition sentence to represent the array.	Enacted: I clean my room. I pull out 3 bins. Each bin gets 5 toys. How many toys do I clean up*? (teacher models how to draw a representation and students draw the same representation on white board)* Our muffin tray has two rows. Each row holds 7 muffins. How many muffins are there?
Ms. Hollyhock	Provided: **How can you use your connecting cubes to show 23?**	Provided: **What number words go with each number? How are the numbers and number words different?**	Provided: **Decide which of these numbers is the greater number and be ready to tell how you know.**
	Enacted: I have unknown amounts of Halloween objects. How can you show me the total number of Halloween objects your group has?	Enacted: **You have a blue card on your desk. You are going to look for a partner who has the same number as you. The number will be shown in different ways (tens and ones, pictures, digits, number word).**	Enacted: **The teacher selected four students to hold a comparison card (e.g., 57 > 34). Students are asked to stand next to the card they think is true. Students are asked to explain why they think the card is true.**

Note. The lesson plans analyzed from *Guiding Kinders* did not include contextualized problems. Bolded word problems do not align with the definition of Contextualized Problems provided in the MQI.

Sub-Finding 3.2: Second grade instruction was more mathematically dense than kindergarten instruction.

Observation scores showed that second grade instruction was more mathematically dense than kindergarten instruction. Based on the MQI whole lesson code, *Lesson is Mathematical Dense*, all lessons scored, *mid* with a mean score of 3.17 (SD = 0.32) (see Table 4.9). However, when analyzing individual grade levels, the data illustrates that kindergarten lessons scored *low*, with a mean score of 2.33 (SD = 0.44) and second grade lessons scored *mid/high* with a mean score of 4.00 (SD = 0.29). I scored this whole lesson code after watching the entire thirty-minute observation. It evaluates the amount of mathematics problems, tasks, or concepts relative to the length of the observed lesson (see Appendix I).

Table 4.9

MQI Whole Lesson Code: Lesson is Mathematically Dense

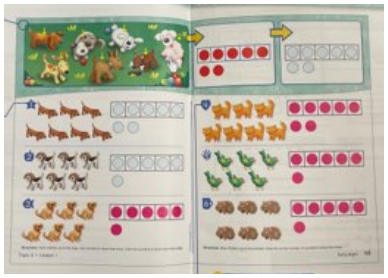
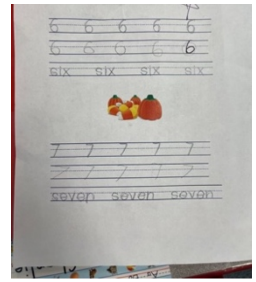
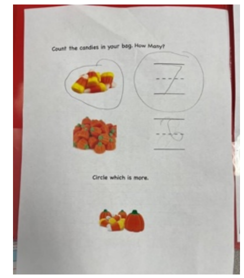
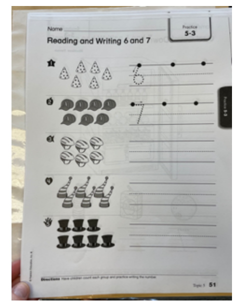
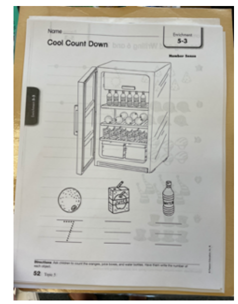
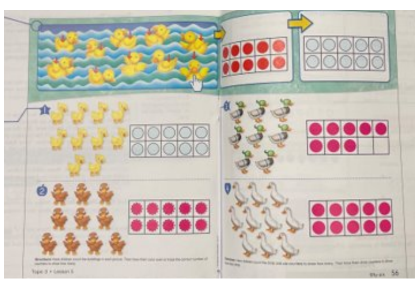
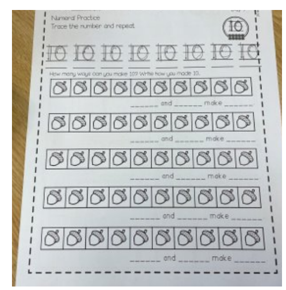
Whole Lesson Code	*n*	*M*	Range	Quality
Lesson is Mathematically Dense				
All Observations	6	3.17 *(0.32)*	1-5	Mid
Kindergarten Observations	3	2.33 *(0.44)*	1-5	Low
Second Grade Observations	3	4.00 *(0.29)*	3-5	Mid/High

Document analysis provided further evidence. Figure 4.2 illustrates the different provided and enacted student practice opportunities during observation one. For example, during observation one, Ms. Aster combined two lessons, and she self-selected the student practice page. Ms. Aster's enacted practice opportunity did not provide students with the opportunity to connect multiple representations (i.e., five frames and objects) and students had six fewer practice problems. It is important to note that the district does not provide Kindergarten teachers with the *enVisionMath* curriculum Guided Practice and Independent practice pages that are pictured. However, the district provides kindergarten teachers with Leveled Homework practice pages. These practice pages provide similar student practice problems. For example, Ms. Coriander could not use the *Guided Practice and Independent Workbook* pages, but she used the curriculum provided *Leveled Homework* practice and enrichment page. This modification provided a similar number and quality of student practice opportunities. Ms. Bellflower used the practice page provided by *Guiding Kinders*. Similar to Ms. Aster, when compared with a comparable practice opportunity in *enVisionMath*, the student practice opportunity did not provide an opportunity for students to connect representations and objects (i.e., ten frames and objects). The *Guiding Kinders* provided practice page included mathematical equations (i.e., _____ and _____ make _____). Finally, the provided student practice opportunities during kindergarten classrooms had a procedural focus.

In contrast, second grade teachers consistently enacted the provided *Guided and Independent Practice Workbook* pages during observations. In Figure 4.3, I provide a photograph of each practice opportunity. Across all student practice opportunities, students can make connections across representations (e.g., part-part-whole model and repeated addition). Ms. Foxglove and Ms. Hollyhock provided a similar number of practice opportunities that included procedural and conceptual focus. Ms. Foxglove's practice opportunity provided 13 problems, with four problems focused on conceptual understanding. Similarly, Ms. Hollyhock's practice opportunity provided 10 problems, with four problems focused on conceptual understanding. Alternatively, Ms. Dodder's practice opportunity provided six problems, with all six problems focused on conceptual understanding. While the total number of practice problems across the grade level was not the same, they all provided four-to-six opportunities for students to practice conceptual understanding.

Figure 4.2

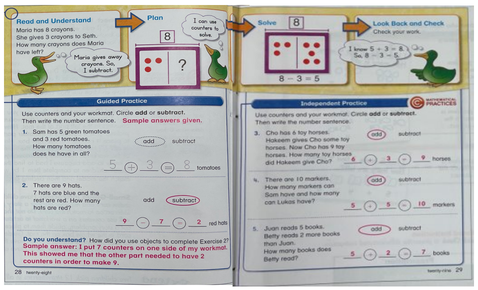
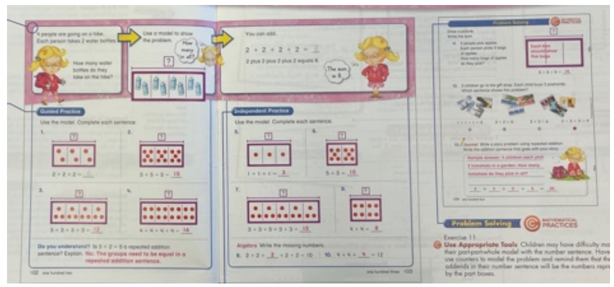
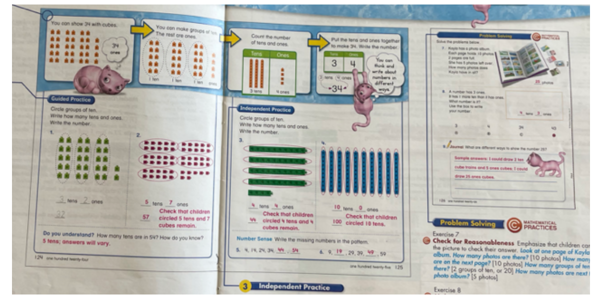
Kindergarten Provided and Enacted Student Practice Opportunities: Observation 1

Teacher	Suggested Practice Opportunity *(enVisionMath)*	Enacted Practice Opportuntiy	
Ms. Aster	 	 	Teacher-selected practice page, unknown source
Ms. Coriander		 	*enVisionMath Leveled Homework* practice pages
Ms. Bellflower	 		*Guiding Kinders* student practice page

Note. Photographs of *enVisionMath* are student practice page answer keys provided in the teacher manual.

Figure 4.3

Second Grade Provided and Enacted Student Practice Opportunities: Observation 1

Suggested and Enacted Practice Opportunity *(enVisionMath)*		
Ms. Dodder	Ms. Foxglove	Ms. Hollyhock
		

Note. Photographs of *enVisionMath* are student practice page answer keys provided in the teacher manual.

Next, observation field notes also suggest that kindergarten students had fewer practice opportunities prior to completing the student practice page. For example, during observation one, Ms. Aster modeled how to count six and seven one time. Then students completed the practice page. Similarly, Ms. Coriander asked students to trace the number seven in the air one time and students watched a short video before they completed the practice page. Finally, Ms. Bellflower asked students to make ten using two addends and more than two addends before they completed the practice page. Ms. Bellflower's initial activity covered a lot of mathematical ground, even though there were only two practice problems.

Alternatively, second grade teachers provided multiple practice problems prior to students' completing practice pages. For example, Ms. Dodder's students completed five word problems. While there are fewer problems enacted, they were meaningful and supported developing the mathematical concepts of the lesson. Ms. Foxglove's students completed 15 procedural repeated addition problems and four conceptual word problems prior to completing the *Guided and Independent Practice Workbook* student practice pages. Last, Ms. Hollyhock students completed three conceptually focused practice problems. She provided the first opportunity during the initial mathematical task where students are asked to sort a random number of Halloween objects into groups of ten. She provided the second opportunity is when she modeled how to decompose a number into tens and ones and how to represent that number is multiple ways (e.g., 32 can be decomposed into three tens and two ones or two tens and twelve ones). She provided the third opportunity when students moved to their seats to represent the number of Halloween objects they sorted in multiple ways. While she provided fewer practice problems, they were meaningful practice opportunities that develop conceptual understanding.

Interview responses might reveal why kindergarten teachers elect not to use the district-provided activity pages. First, Ms. Coriander shared why kindergarten does not use the *Guided and Independent Practice Workbook* pages saying, “I feel as though it’s a little more difficult for them to stay focused using a workbook [Guided and Independent Practice Pages] with more than just a one page” (interview, November 10, 2022). She also shared that kindergarten teachers originally had access to the *Guided and Independent Practice Workbook* pages but elected not to renew the subscription. stating, “We had the workbook, but we have not renewed that in a few years.” (interview, November 10, 2022). Adding to this, Ms. Aster shared why she doesn’t always use the *enVisionMath Leveled Homework* practice pages stating, “I don’t think the directions in the *enVision’s* books are very user friendly. If I have a kid, that’s absent, and I send the page [Leveled Homework] home, the parents won’t have any idea what they’re supposed to do.” (interview, November 2, 2022)

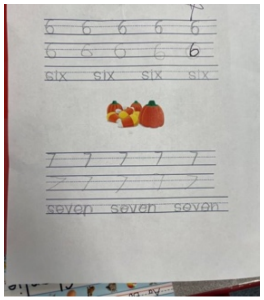
Inconsistent Grade-Level Practice Opportunities. Finally, document analysis revealed that student practice opportunities were inconsistent from kindergarten to kindergarten classroom while they were consistent from second grade to second grade classroom (see Figure 4.4). During all observed lessons, second grade teachers used the *enVisionMath* curriculum provided *Guided and Independent Practice Workbook* pages. For example, Ms. Aster and Ms. Coriander implemented the same lesson objective during observation one, but they provided different student practice opportunities. Conversely, Ms. Bellflower’s third observation and Ms. Foxglove’s first observation implemented the same lesson objective and they provided the same practice opportunities.

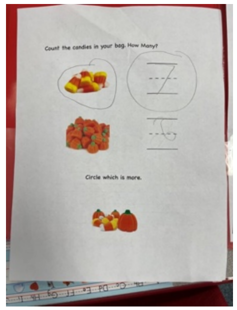
Figure 4.4

Comparison of Enacted Student Practice Opportunities

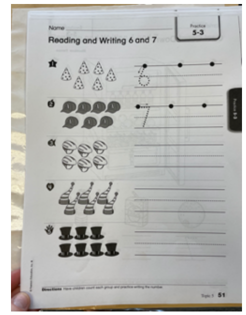
Kindergarten

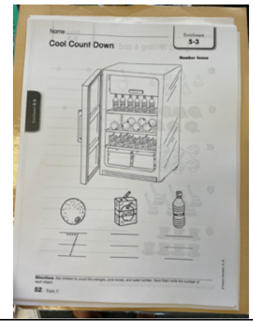
Ms. Aster





Ms. Coriander

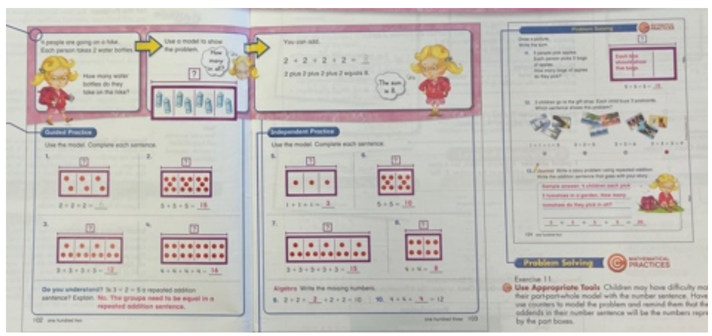




Second Grade

Ms. Dodder

Ms. Foxglove



Note. Kindergarten teachers do not have access to the Guided and Independent workbook pages. I did not observe Ms. Bellflower teaching six and seven or Ms. Hollyhock teaching repeated addition. Therefore, examples are not included from their observations.

Summary

Chapter 4 presented data collected using survey questions, video observations, document collection, and interview responses. Quantitative and qualitative data was integrated to determine the following findings and sub-findings that were presented in this chapter:

- Finding 1: Most teachers report using the district-provided curriculum (i.e., *enVisionMath)* as their main mathematics materials, though some teachers supplemented heavily with other instructional materials.
    - Sub-Finding 1.1: Most teachers modified instructional materials to some degree.
    - Sub-Finding 1.2: Teachers believe the district requires them to use the district-provided instructional materials.
- Finding 2: The observed features of mathematical quality ranged from *Not Present* to *Mid-level* quality.
    - Sub-Finding 2.1: Mathematics instruction was consistently error-free and clear.

      Sub-Finding 2.2: Most instructional segments included classroom work connected to mathematics.
    - Sub-Finding 2.3: Students did not consistently communicate about mathematics.
    - Sub-Finding 2.4: Most mathematical tasks were low cognitive demand.
- Finding 3: The relationship between observed mathematical quality of instruction and teachers' use of instructional materials varied grade level to grade level.
    - Sub-Finding 3.1: Second grade instruction included contextualized word problems. Kindergarten instruction did not include contextualized word problems.
    - Sub-Finding 3.2: Second grade instruction was more mathematically dense than kindergarten instruction.

Chapter 5 will provide recommendations to key stakeholders at Hillside Elementary School grounded in these findings.

Chapter 5: Recommendations

Providing high-quality mathematics instruction is a complex and challenging task that requires a unique set of skills and knowledge (Biech, 2017; Hill & Charalambous, 2012a). As trained generalists, this is particularly challenging for elementary teachers. At Hillside Elementary School, the district leaders and teachers are working to improve student mathematics achievement across all elementary grades. Specifically, they are interested in providing support (e.g., high quality instructional materials and professional learning opportunities) to teachers to improve students' opportunities to learn in mathematics. Therefore, it is necessary to understand how elementary teachers use instructional materials and the mathematical quality of instruction enacted. Through this descriptive study, I described the instructional materials teachers use to plan mathematics instruction and the mathematical quality of observed instruction at Hillside Elementary School. Using the conceptual framework presented in chapter one, I integrated quantitative and qualitative data to generate findings to address the following research questions:

1. What instructional materials do K-2 teachers report using to plan mathematics instruction at Hillside Elementary School?
2. What is the observed quality of mathematics instruction in K-2 classrooms at Hillside Elementary School?
3. What is the relationship between observed mathematics instructional quality and the instructional materials K-2 teachers used to plan mathematics instruction at Hillside Elementary School?

In this chapter, I use this study's findings, relevant literature, and teacher perspectives to give recommendations to Hillside Elementary School. The focus of the recommendations is to inform future curriculum initiatives and PLO to potentially improve the quality of mathematics instruction. I present the following recommendations to district leaders at Hillside Elementary School:

- Recommendation 1: Develop a strategic implementation plan for provided instructional materials.
    - Action Step 1.1: Draft implementation policy
    - Action Step 1.2: Provide ongoing professional learning opportunities to support implementation plan
    - Action Step 1.3: Monitor effectiveness of implementation policy
- Recommendation 2: Provide ongoing professional learning opportunities focused on enacting common core aligned student practices.
    - Content Focus 2.1: Student Opportunities to Communicate About Mathematics
    - Content Focus 2.2: High Cognitive Demand Mathematical Tasks
- Recommendation 3: Require systematic modification of provided instructional materials within and across grade levels.
    - Action Step 3.1: Develop a strategy for systematic modification
    - Action Step 3.2: Provide collaborative planning time to modify instructional materials
    - Action Step 3.3: Evaluate effectiveness of modifications

Recommendation 1: Develop a strategic implementation plan for district-provided instructional materials.

Findings from this study suggest that teachers are using provided instructional materials in different ways. Teachers are heavily supplementing lessons with not-as-trustworthy instructional materials, including materials from *TPT* and *Pinterest*. Shapiro and colleagues

(2019) characterized not-as-trustworthy materials as materials that have not undergone expert-review for content quality. Last, the district does not provide kindergarten teachers with complete access to all components of the district-provided curriculum (i.e., *Guided and Independent Practice Workbook* pages). This suggests students experience different instructional opportunities across and within grade levels.

Given that mass-published curricula cannot be designed for individual school contexts, it might not be possible to achieve complete implementation fidelity of curricular materials (Remillard, 2005). Research suggests that curricular materials provide an important guide for teachers, but it is important that teachers adapt and modify materials in ways that support their specific students and the local school context (Cohen, 2011). However, without an implementation policy with specific guidance, the quality of learning opportunities will probably vary from classroom to classroom. Therefore, the district should identify specific components of district-provided instructional materials that teachers are required to implement, and also identify the components that teachers may modify. This will support the coherent implementation of district-provided instructional materials within a specific school context (Cohen, 2011) and provide students at Hillside Elementary School with consistent opportunities to learn.

Based on the findings, I recommend the district requires all teachers to implement the *Problem-Based Interactive Learning* activity and *Guided and Independent Practice Workbook* pages. Findings suggested that these components of *enVisionMath* supported improved mathematical quality of instruction. For example, The *Problem-Based Interactive Learning* activity provides contextualized word problems and has the potential to increase cognitive demand of enacted mathematical tasks. The *Guided and Independent Practice Workbook* pages frequently connect different mathematical representations, improving the richness of mathematics. More importantly, all students, regardless of teacher, would receive an equal number of practice opportunities for each lesson. Finally, the curriculum-provided student practice pages were more mathematically dense than the teacher-selected student practice pages. These practice pages provided more practice problems and problems that developed students' conceptual understanding of the mathematical concept.

Action Step 1.1: Draft implementation policy

The district should develop a strategic implementation policy for all district-provided instructional materials. The implementation policy should clearly outline the components of the district-provided instructional materials that are required to implement and the components that teachers may adapt and modify (Tezera, 2019). Educational polices that have proved effective have the following characteristics: collaborative development with key stakeholders (i.e., teachers), feasible to implement, and logical. Consequently, teacher representatives should work collaboratively with administration to draft an implementation policy that is feasible to execute in the school context. Finally, I recommend that the implementation policy take effect after the 2023-2024 curriculum purchase because this provides the necessary time to thoughtfully develop a logical policy and implementation plan.

Key stakeholders were concerned that teachers would resist an implementation policy; however, interview responses suggest this may not be the case. During the interview, Mrs. Aster shared she believes the district should provide teachers with a curriculum, "…but also give some flexibility to be creative with it. Like these are the lessons that you need to cover. Here's one way that you can do it." Building on this, Mrs. Bellflower agreed she would implement a curriculum with fidelity if it was high quality commenting, "I need to find what's best for my students, so I guess it depends on [if] our program is bad." Finally, Mrs. Dodder argues, "I think they definitely should be doing the curriculum… I feel like they're going to say, use the curriculum, but you can tweak it or add what you want to it, and I think that certain parts are okay. But then, you have some people veering way too much this way or too much that way. It's like not going to be consistent." This evidence suggests that teachers are open to an implementation policy if the plan provides some flexibility, is used with a high-quality instructional material, and there are clear expectations for required components.

Action Step 1.2: Provide ongoing professional learning opportunities to support implementation plan

Teachers need ongoing PLO to unpack and utilize instructional materials. High quality PLO include the following characteristics: instructive, reflective, active, collaborative, and substantive (Martin et al., 2014). Therefore, for the implementation policy to be enacted meaningfully, the district should provide PLO for teachers to improve the teacher-curriculum relationship, which will support the enactment of the developed implementation policy. I further describe the qualities of the recommended PLO in the following sections.

Instructive. Researchers suggest to contextualize PLO to a specific school context and to focus on the development of teachers' content knowledge (D. K. Cohen, 2011; Martin et al., 2014; Webster-Wright, 2009). It is important to consider what knowledge and skills teachers at Hillside Elementary School already have and to make meaningful connections between their knowledge and skills and the PLO. Ms. Hollyhock shared her frustration about non-instructive professional development stating, "Stop giving us trainings that we had eight years ago, and then repeat them and teach me how to use flashcards. I've been teaching for…[many] years" (interview, November 3, 2022). Therefore, I recommend the PLO develops new mathematical content knowledge for teaching while making explicit connections to district-provided instructional materials. This will allow teachers to apply their new knowledge and ideally translate this knowledge through the enactment of curricular materials.

Reflective. PLO should ask teachers to reflect on their current teaching practices, focusing specifically on how they do or do not utilize district-provided instructional materials. Research suggests that when teachers reflect on their current practices, they might be more willing to adjust and/change their practices (Webster-Wright, 2009). At the start of the PLO, teachers should reflect on how they use the current district-provided instructional materials and how they might like to use future district-provided instructional materials.

Active. Provided PLO should extend teachers' current knowledge (Cohen, 2011), engage teachers intellectually, and present more than a body of knowledge (Duncan et al., 2007). Teacher perspectives highlight they want to be actively involved during PLO and they provide specific examples to illustrate what "actively involved" means to them. Ms. Aster stated, "[I want] training on it. That would be helpful. Actually, maybe even attending a class about teaching it [the curriculum] with the materials, in person, and not just watching a video about it [the curriculum] (interview, November 2, 2022). Similarly, Ms. Bellflower shared, "I feel like we need to have more hands-on training with everything in front of us, so that we can see it, and we can work through it" (interview, November 1, 2022). Ms. Dodder and Ms. Hollyhock suggest that PLO include modeling of the expected enactment of instruction. First, Ms. Dodder stated, "Can you model a lesson for me? Just so I can see it how it's supposed to be done and [then] go through each component [to show] what's available to us" (interview, November 1, 2022). Second, Ms. Hollyhock said, "Just model a lesson for me, just one. I want to see it from start to finish. How you would teach this lesson? I think that'd be super helpful." Therefore, I recommend the PLO clearly incorporate district-provided instruction materials and provide teachers with hands-on, interactive experiences to unpack these materials.

Collaborative. Researchers found that collaborative PLO across and within grade levels support instructional change (Desimone et al., 2002). Further, some researchers suggest that ongoing, embedded collaboration with instructional coaches might improve instructional practices (Dagen & Bean, 2014). Teachers at Hillside Elementary School want to learn through collaboration. Ms. Aster and Ms. Foxglove both requested support from a mathematics coach. Ms. Aster stated, "…even somebody, like a math coach, that could be available to help and that would know the curriculum and how to [implement the curriculum] (interview, November 2, 2022). Expanding on this, Ms. Foxglove stated:

> It would be really nice if we had a math coach again. It would be helpful to have someone come in with you, one to one, and give you some feedback… I think that could also take some of the work off our plates if you had a person like that because they could work with the person who's piloting it [new curriculum], and maybe then their job is to figure out. Okay, this isn't working. I'll rearrange it, and then you try it and tell me what you think? (interview, November 8, 2022)

Finally, second grade teachers shared during interviews that they collaborated within grade-level and across the district with the other second grade team to modify the provided scope and sequence for the mathematics curriculum. This evidence suggests that teachers at Hillside Elementary School value opportunities to collaborate. I recommend that the district considers employing an instructional coach to facilitate collaboration and provide support for implementing instructional materials.

Substantive. Research suggests that high-quality PLO is substantive and has an extended duration (Desimone et al., 2002; Martin et al., 2014). Further, teacher perspectives provide meaningful insight into how substantive the PLO should be to implement new district-provided instructional materials. First, Ms. Aster highlighted that a one day training did not provide enough support for a previous district-provided curriculum, stating, "Sometimes they [trainers] teach us how to use it at an in service in the middle of August, where we can't actually dig into it. Here it is in November, and I don't actually remember how to do that" (interview, November 2, 2022). Ms. Bellflower requested "proper" training sharing the following, "We have to have proper training. Oh, watch this video for an hour [is not enough] … I feel like every time we get something new, that is what they do…" (interview, November 1, 2022). Finally, Ms. Dodder argues that providing enough training time allows for teachers to "… absorb and understand…" and the ability to "…take the time to think ahead and plan" (interview, November 1, 2022). Therefore, I recommend the district dedicate the 2023-2024 school year to providing ongoing, embedded PLO to teachers to support the implementation of the district-provided instructional materials.

Action Step 1.3: Monitor effectiveness of implementation policy

After district administration and teachers agree on an implementation policy for the new instructional material, it is important to implement and monitor the effectiveness of the policy (Tezera, 2019). Findings suggested teachers believed they were implementing the district-provided instructional materials with limited modifications, but observations and document analysis revealed this was not the case. It would be important for district administration to monitor the effectiveness of the implementation policy to ensure it is being enacted in the intended way.

Recommendation 2: Provide ongoing professional learning opportunities focused on enacting common core aligned student practices.

As stated previously, PLO need to be ongoing, instructive, actively engaging for teachers, provide moments for reflection, and be collaborative (Martin et al., 2014). Further, researchers argue that the selected content focus is a very important feature of PLO (Desimone, 2009; Desimone et al., 2002). Specifically, learning should develop content knowledge and explain how students learn the content knowledge. Prior research suggests that doing this has the potential to increase teacher knowledge and skills and improve instruction practice with the potential to improve student achievement. Findings suggest two areas of mathematical instruction that have opportunities for improvement: *Student Opportunities to Communicate About Mathematics* and *High Cognitive Demand Mathematical Tasks*. Given these results, I recommend that the following content focuses for future PLO.

Content Focus 2.1: Student Opportunities to Communicate About Mathematics

Teacher and student mathematical talk is an important feature of high-quality instruction (Clements et al., 2013; Hufferd-Ackles et al., 2004; Rittle-Johnson, 2006). During 2023-2024 academic school year, I propose the district provides PLO focused on improving student opportunities to communicate about mathematics. I selected this content focus because all teachers can implement this instructional practice regardless of their use of instructional materials. At the conclusion of PLO, teachers should be able to answer the following questions:

- What is mathematical talk? (instructive: content knowledge)
- Why is it important for students to communicate about mathematics? (instructive: content knowledge)

- Am I incorporating opportunities for students to communicate about mathematics? (reflective)
- How do I provide opportunities for students to communicate about mathematics? (instructive: pedagogical knowledge)
- Can I learn from other teachers who are already doing this? (collaborative)

Additionally, Hillside Elementary School has optional professional learning cohorts for teachers. I recommend using the cohort structure to provide ongoing, active, and collaborative PLO specific to this content focus. During cohort hours, teachers can discuss the challenges and successes of implementing mathematical talk, problem-solve challenges, and share instructional materials that supported successes.

Content Focus 2.2: High Cognitive Demand Mathematical Tasks

High cognitive demand mathematical tasks are an important feature of high-quality mathematics instruction (Stein et al., 1996; Stein & Smith, 1998). However, researchers found teacher-selected online supplemental curriculum materials are likely to present low cognitive demand tasks (Polikoff & Dean, 2019; Sawyer et al., 2019). Findings suggest teachers at Hillside Elementary School are not consistently providing high cognitive demand tasks. Consequently, I recommend PLO focus on identifying, evaluating, and implementation high cognitive demand mathematical tasks during the 2024-2025 academic year. This is the second content focus because it is harder to implement and might require additional time for teachers to execute effectively. Furthermore, I recommend identifying and evaluating cognitive demand tasks using the developed implementation policy. Teachers should be able to answer the following questions at the conclusion of PLO.

- What is a mathematical task? (instructive: content knowledge)

- What are the characteristics of high cognitive demand and low cognitive demand tasks? (instruction: content knowledge)
- Why does cognitive demand matter for student learning? (instructive: content knowledge)?
- Are the mathematic tasks I'm currently implementing high or low cognitive demand? (reflective)
- How do I evaluate a mathematical task for cognitive demand? (instructive: pedagogical knowledge)
- How do I modify a mathematical task to increase cognitive demand? (instructive: pedagogical)
- Can I learn from other teachers who are already doing this? (collaborative)

This should be the content focus of cohort hours during the 2024-2025 academic year. Professional learning cohorts support active, collaborative, and ongoing PLO.

Recommendation 3: Require systematic modification of provided instructional materials within and across grade levels.

Research suggests that it is important to help teachers develop skills to effectively and critically evaluate instructional materials before they adapt and modify instructional materials (Ben-Peretz, 1990; Schrum, 2002). This is necessary given that research argues teachers adapt or select low cognitive demand mathematical tasks (Sawyer et al., 2019). Findings from this study suggest that teachers are modifying instructional materials in different ways, but most modifications reduced rigor (i.e., removing contextualized word problems). Given this, the quality of instruction varied from grade level to grade level. Specifically, second grade teachers used contextualized word problems and kindergarten teachers do not. Additionally, kindergarten teachers provided different student practice opportunities classroom-to-classroom and these practice opportunities were less mathematically dense than second grade student practice opportunities. Alternatively, second grade provided the same student practice opportunities classroom-to-classroom. Therefore, I recommend requiring systematic modification of any provided instructional materials within and across grade levels after successful implementation of recommendation one and two. In the remainder of the section, I provide three action steps to enact this recommendation.

Action Step 3.1: Develop a strategy for systematic modification.

Research suggests that a variety of factors influence a teacher's decision to adapt or modify an instructional material (Ben-Peretz, 1990; Remillard, 2005; Wang et al., 2021). For example, teachers will modify instructional materials based on their perceived quality and/or if they believe the instructional materials do not meet the needs of their students. Ms. Aster stated, "Sometimes when I'm planning, I will combine some lessons together just based off of where my kids are." (interview, November 2, 2022). She also shared, "I wish it [*enVisionMath*] would have been a little bit more rigorous with the option to back up if I need to." Similarly, Ms. Bellflower stated:

> I think it [*enVisionMath*] was kind of slow moving, and the worksheets for kindergarten, I thought, were like two problems on a page. It was very, I want to say babyish. I felt like my kids were beyond that. (interview, November 1, 2022)

Teachers at Hillside Elementary School want to modify instructional materials to increase rigor and meet the needs of their learners. However, the enacted modifications did not support high-quality mathematics instruction. Therefore, providing teachers with a modification checklist would support their ability to make modifications to instructional materials to meet the needs of their learners and increase rigor without ignoring the implementation policy suggested in recommendation one.

Research suggests that teacher modifications frequently reduce rigor and task cognitive demand (Polikoff & Dean, 2019; Rich et al., 2022). Furthermore, Schroeder and Curcio (2022) argue teachers should develop 21st-Century Critical Curriculum Literacy to develop skills to evaluate, modify, and adapt supplemental materials. Therefore, using their framework as a guide, I recommend introducing a modification flowchart to be used in conjunction with detailed meeting notes to support collaborative and meaningful modifications to instructional materials during the 2025-2026 academic school year (see Appendix J). This would provide support for systematic modification of instructional materials and generate an audit trail for administrative leadership to monitor.

Action Step 3.2 – Provide collaborative planning time to modify instructional materials.

As noted, collaboration is a key feature of effective PLO (Desimone, 2009; Martin et al., 2014). Given this, I recommend providing grade-level teams with collaborative opportunities to use the modification checklist to carefully consider and evaluate any potential modifications to instructional materials in order to maintain high-quality, equitable learning opportunities for all students. Teachers at Hillside Elementary School are open to making grade-level modifications to district-provided instructional materials which provide consistent learning opportunities for all students. Mrs. Aster stated, “that would be good [to work with my grade-level team], because then it wouldn't be everybody trying to recreate the wheel.” Agreeing with this, Mrs. Bellflower said, “I actually like working together and coming up with [instructional materials] … I mean, I know every question is different, and kids are different, but for the most part they’re all going to be in that general area, right? And why not have other resources? Other brains, you know what I mean. The more we get together… I would love to collaborate…it's going to benefit all of us." Finally, Ms. Foxglove recommended working across grade-levels stating:

> I think there's a lot of value in cross-grade planning… there's several years that I'll go to third grade, and I'll be like, "What do they struggle with when they come to you?" ... So, I think that, allowing that collaborative time is really important and valuable (interview, November 8, 2022).

This evidence suggests that teachers are interested and excited to collaborate and critically evaluate instructional materials in service of student learning. Currently, kindergarten teachers and second grade teachers do not have a common planning time. Additionally, there are no structures in place to support purposeful collaboration at Hillside Elementary School. Therefore, teachers would benefit from a common planning time and clear structures for collaboration.

Action Step 3.3 – Evaluate and monitor systematic modifications.

Finally, I recommend that district leadership evaluate and monitor systematic modifications regularly to determine if these modifications align with the district implementation policy and features of high-quality mathematics instruction. If the system is not monitored, it is unclear if teachers will systematically modify instructional materials as a grade-level team. Additionally, I recommend evaluating and comparing modifications across grade-levels to determine if curricular coherence has been jeopardized at any point. Specifically, administration should evaluate how implemented modifications might positively or negatively impact instruction in future grades.

Limitations

In considering recommendations, there are important limitations that should be noted. First, this study focused on K-2 teaching. Further research is necessary to employ these recommendations for teachers in grades 3-4. Second, this study focused on teaching and not on student learning. Future studies would need to evaluate student learning and account for differences across learners. Given the equity issues that pervade online marketplaces (Gallagher et al., 2019; Polikoff & Dean, 2019), district leaders and teachers should examine supplemental materials through an equity lens. This would provide an opportunity to select instructional materials that do not perpetuate harmful beliefs. Simultaneously, the district leaders and teachers can select (or modify) instructional materials in a way that represents and respects diverse student backgrounds.

Summary

Chapter five presented recommendations and action steps for district leadership at Hillside Elementary School. These recommendations were curated as a result of the findings of the study, relevant literature, and teacher perspectives gathered during interviews. In figure 5.2, by identifying potential outcomes, I illustrate the translation between research questions, findings, and recommendations to practice. The research questions, findings, and recommendations read horizontally. Recommendation one and recommendation three support consistent use of district-provided instructional materials. Recommendation two supports improved mathematical quality of instruction. Collectively, the short-term outcomes will ideally lead to increased student opportunities to learn mathematics with the ultimate goal of improved mathematics achievement at Hillside Elementary School.

Figure 5.2

Summary of Findings, Recommendations, and Potential Outcomes

<table>
<tr><th colspan="3">Problem of Practice: Mathematics Achievement at Hillside Elementary School</th><th>Short Term Outcomes</th><th>Long Term Outcomes</th></tr>
<tr><td>RQ1: What instructional materials do K-2 teachers report using to plan mathematics instruction at Hillside Elementary School?</td><td>Finding 1: Most teachers report using the district-provided curriculum (i.e., enVisionMath) as their main mathematics materials, though some teachers supplemented heavily with other instructional materials.
Sub-Finding 1.1: Most teachers modified instructional materials to some degree.
Sub-Finding 1.2 Teachers believe the district requires them to use the district-provided instructional materials.</td><td>Recommendation 1: Develop a strategic implementation policy for provided instructional materials.
Action Step 1.1: Draft implementation policy.
Action Step 1.2: Provide ongoing professional learning opportunities to support implementation plan.
Action Step 1.3: Monitor effectiveness of implementation policy.</td><td rowspan="3">Consistent Use of District-Provided Instructional Materials

Improved Mathematical Quality of Instruction</td><td rowspan="3">Increased Student Opportunities to Learn Mathematics
↓
Improved Mathematics Achievement at Hillside Elementary School</td></tr>
<tr><td>RQ2: What is the observed quality of mathematics instruction in K-2 classrooms at Hillside Elementary School?</td><td>Finding 2: The observed features of mathematical quality ranged from Not Present to Mid-level quality.
Sub-Finding 2.1: Mathematics instruction was consistently error-free and clear.
Sub-Finding 2.2: Most instructional segments included classroom work connected to mathematics.
Sub-Finding 2.3: Students did not consistently communicate about mathematics.
Sub-Finding 2.4: Most mathematical tasks were low cognitive demand.</td><td>Recommendation 2: Provide ongoing professional learning opportunities focused on enacting common core aligned student practices.
Content Focus 2.1: Student Opportunities to Communicate About Mathematics
Content Focus 2.2: High Cognitive Demand Mathematical Tasks</td></tr>
<tr><td>RQ3: What is the relationship between observed mathematics instructional quality and the instructional materials K-2 teachers use to plan mathematics instruction at Hillside Elementary School?</td><td>Finding 3: The relationship between observed mathematical quality of instruction and teachers' use of instructional materials varied grade level to grade level.
Sub-Finding 3.1: Second grade instruction included contextualized word problems. Kindergarten instruction did not include contextualized word problems.
Sub-Finding 3.2: Second grade lessons were more mathematically dense than kindergarten lessons.</td><td>Recommendation 3: Require systematic modification of provided instructional materials within and across grade levels.
Action Step 3.1: Develop a strategy for systematic modification.
Action Step 3.2: Provide collaborative planning time to modify instructional materials.
Action Step 3.3: Evaluate effectiveness of modifications.</td></tr>
</table>

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Appendix A

Survey Email Notifications

Pre-Notification Email

<ADD DATE>

Dear <NAME>,

In a couple days you will receive an email invitation to participate in an online survey conducted by Mountainview School District. The survey will provide us with important information about how you think about and plan for mathematics instruction at Hillside Elementary School. Your feedback will help Mr. Smith and I understand how we might improve the way we support you in your classroom and the students at Hillside Elementary School. I am writing in advance to ask you to support our endeavor by participating in this important survey. Please be assured that your response will be confidential. If you would like further information about the survey, please contact the principal investigator Katie Waddell at 814-720-2844 or at kjw7n@virginia.edu.

Thank you for your participation. I appreciate your continued efforts to provide exceptional learning opportunities for the students at Hillside Elementary School.

Sincerely,

Katie Waddell

Doctoral Candidate, University of Virginia

UVA IRB-SBS #5266

Action Requested: Survey Link

<ADD DATE>

Dear <NAME>,

Mountainview School District is currently conducting an online survey of K-2 teachers. As part of our district-wide effort to meet students where they are to empower them to become all they are capable of being, we are interested in understanding how you think about and plan for mathematics instruction at Hillside Elementary School. Questions are about the instructional materials you use to plan for and enact instruction.

Your personal link to the survey is:

Take the Survey <Hyperlink Words>

Or you may copy and paste the URL below into your internet browser: <ADD HERE>

The information collected by this survey will be used to improve the way Mr. Smith and I support you in your classroom and the students at Hillside Elementary School. Your responses will be confidential. Mr. Smith will not have access to individual responses. If you have any questions about the survey, please contact the principal investigator Katie Waddell at 814-720-2844 or at kjw7n@virginia.edu. Thank you in advance for participating.

Sincerely,

Katie Waddell

Doctoral Candidate, University of Virginia

UVA IRB-SBS #5266

Survey Link: Final Notification

<ADD DATE>

Dear <NAME>,

We recently sent you a request to participate in an important survey conducted by Mountainview School District. Your feedback is highly valuable to us and will help our district-wide effort to meet students where they are to empower them to become all they are capable of being. Please consider supporting this endeavor by completing the survey. If you have any questions about the survey, please contact the principal investigator Katie Waddell at 814-720-2844 or at kjw7n@virginia.edu.

Your personal link to the survey is:

Take the Survey <Hyperlink Words>

Or you may copy and paste the URL below into your internet browser:

<ADD HERE>

Your responses will be confidential. Thank you for participating.

Sincerely,

Katie Waddell

Doctoral Student, University of Virginia

UVA IRB-SBS #5266

Appendix B

Interview Protocol

UVA IRB-SBS #5266

Title: AN EXAMINATION OF ELEMENTARY TEACHERS' MATHEMATICAL QUALITY OF INSTRUCTION AND USE OF INSTRUCTIONAL MATERIALS

Interviewee: Mrs. Bellflower

Date and time: 11-1-2022, 1:30-2:00pm

Interview

Consent

- Thank you for agreeing to participate in this interview and this research project. The goal of the interviews is to learn more about how you think about planning and teaching mathematics.
- Before we begin, I wanted to let you know that you can end the interview at any point. If any of the questions or discussion makes you feel uncomfortable or you want to stop for any reason, please let me know.
- I will be audio-recording this interview to ensure accuracy in my write up of the interview. If you would like me to stop recording at any point or have any concerns about being recorded, please let me know. After transcribing the interview, I will delete the recording.
- This interview will be about 30 minutes long. If you need me to stop or pause it at any point before then, just let me know.

General background

- How long is your typical mathematics instruction block?
    - Do you teach Calendar Math? (If yes, continue with follow-up questions)
        - When do you teach Calendar Math?
        - What mathematics topics are covered?

Instructional Planning

I'm interested in understanding how teachers use instructional materials to plan for mathematics instruction. The next set of questions will be about the instructional materials you use to teach mathematics.

- Tell me about the materials you use to plan the (first/second/third) lesson I observed.
    - Do you use the district scope and sequence?
    - Did you use the district-provided curriculum *enVisionMath* or another curriculum?

- **YES:**
    - What parts of the curriculum do you use? (If *enVisionMath*, continue with follow-up questions)
        - Research says…
        - Daily Common Core Review
        - Introduction
        - Guided/independent practice
        - Differentiated instruction
        - Quick check
        - Reteaching/Enrichment Homework
        - Intervention lesson

- **NO:**
    - Why did you decide to use different instructional materials?
        - Why did you decide to purchase a curriculum on Teachers Pay Teachers?
        - What characteristics where you looking when you selected the curriculum?
    - How do the instructional materials compare to *enVisionMath*?
        - Strengths/Weaknesses
    - Do you use any part of the *enVisionMath* curriculum for planning instruction?

- How did you determine which activities to use from your identified instructional materials and which activities to modify?
    - Are these typical strategies you use for every math lesson?

- How did you supplement the instructional materials for this mathematics lesson?
    - Do you modify/adapt/create your own materials? Describe the process that you use to determine if you will modify/adapt/create your own materials.
        - During lesson one, you used math stackers instead of number cubes and the sorting mat suggested in the instructional materials. Why did you decide to make this adaption?
        - Your identified instructional materials suggest a literacy connection with a read aloud text. Do you always read the books suggestion? If so, when?
        - Your identified instructional material provides vocabulary. Do you explicitly teach this?

Mathematics Instruction

I observed you teach three mathematics lesson. The rest of the questions will be about your mathematics instruction.

- During the first lesson (i.e., Ways to Make Ten), you asked students to show different ways to make ten with the math stackers at the start of the lesson using 2 addends and using more than 2 addends.

    - Why did you did you prioritize this?

    - How did your instruction materials influence this decision?
        - In your instructional materials, it did not suggest that you ask students to make ten using more than two addends. Why did you make this adjustment during your instruction?

- During the second lesson (i.e., Comparing Numbers 1-5), you asked students engage in math talk by asking their peers questions about their leaf model.
    - Why did you prioritize this?
    - How did your instructional materials influence this decision?
        - Are the 'math talk speech bubbles' provided in your instructional materials? How often do you use these?
- During the third lesson (i.e., Comparing Numbers 6-10), you used multiple representations to compare numbers 6-10.
    - Why did you prioritize this?
    - How did your instructional materials influence this decision?
        - Does the author of your instructional materials encourage multiple representations throughout the resource?

Teacher's Beliefs and Attitudes

- How do you feel about the curriculum?
    - How do you think teachers should use a provided curriculum?
    - How would you be best supported when given and asked to implement a new curriculum?
    - What qualities would you prioritize if you were selecting a new mathematics curriculum?

- How do you feel about teaching mathematics?

Note. *Interview protocols were individualized to each participant. Additional interview protocols are available upon request.*

Appendix C

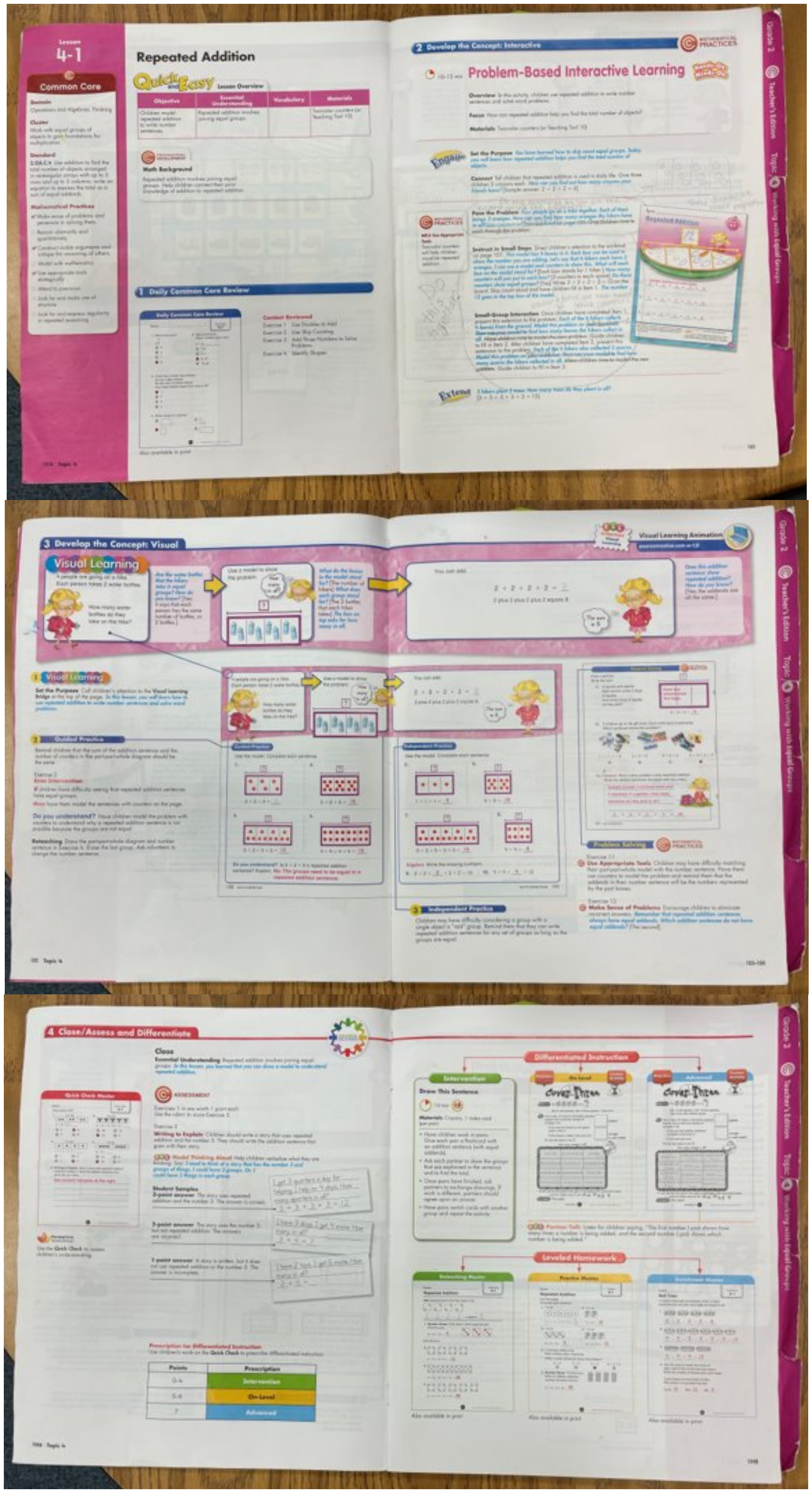
Qualitative Codebook Excerpt

	a priori codes		
Category	**Code**	**Definition**	**Example**
Types of Modifications	Increase Rigor	Teacher adjusts the provided lesson to increase the task cognitive demand.	I think some but one of the students started making other ways [multiple addends to make 10], and then, like oh, you know, just let them explore. Let them see. So that kind of wasn't planned.
	Reduce Rigor	Teacher adjusts the provided lesson to reduce the task cognitive demand.	But I definitely will try, especially with [the] 'Do You Understand', to give a model for them.
Instructional Practices	Conceptual Knowledge	Teacher selects instructional practices that support the development of conceptual knowledge.	I think it's important for them to understand different ways that they can identify things…So, it was just one of my opportunities to help children to gain knowledge in more than just the number, identification, and, the value of the number.
	Procedural Knowledge	Teacher selects instructional practices that support the development of procedural knowledge.	No, this was more me, seeing that there just wasn't enough practice
	emergent codes		
Types of Modifications	Cute, Kid-Friendly	Teacher adjusts to add clipart, food, coloring. etc. Teacher adjusts to align with theme (e.g., Halloween).	But sometimes I want things to be more colorful, or like more fun for the kids.
	Engagement	Teacher adjusts to improve student engagement (hands-on, manipulatives).	Well, with the math stackers, like they have the number, and then they have like the sections, so they're able to just visually see.
Instructional Practices	Multiple Representations	Teacher uses multiple representations to illustrate a mathematics concept(s).	I think it's important for them to understand different ways that they can identify things. It's building a foundation.

Note. *Full codebook available upon request.*

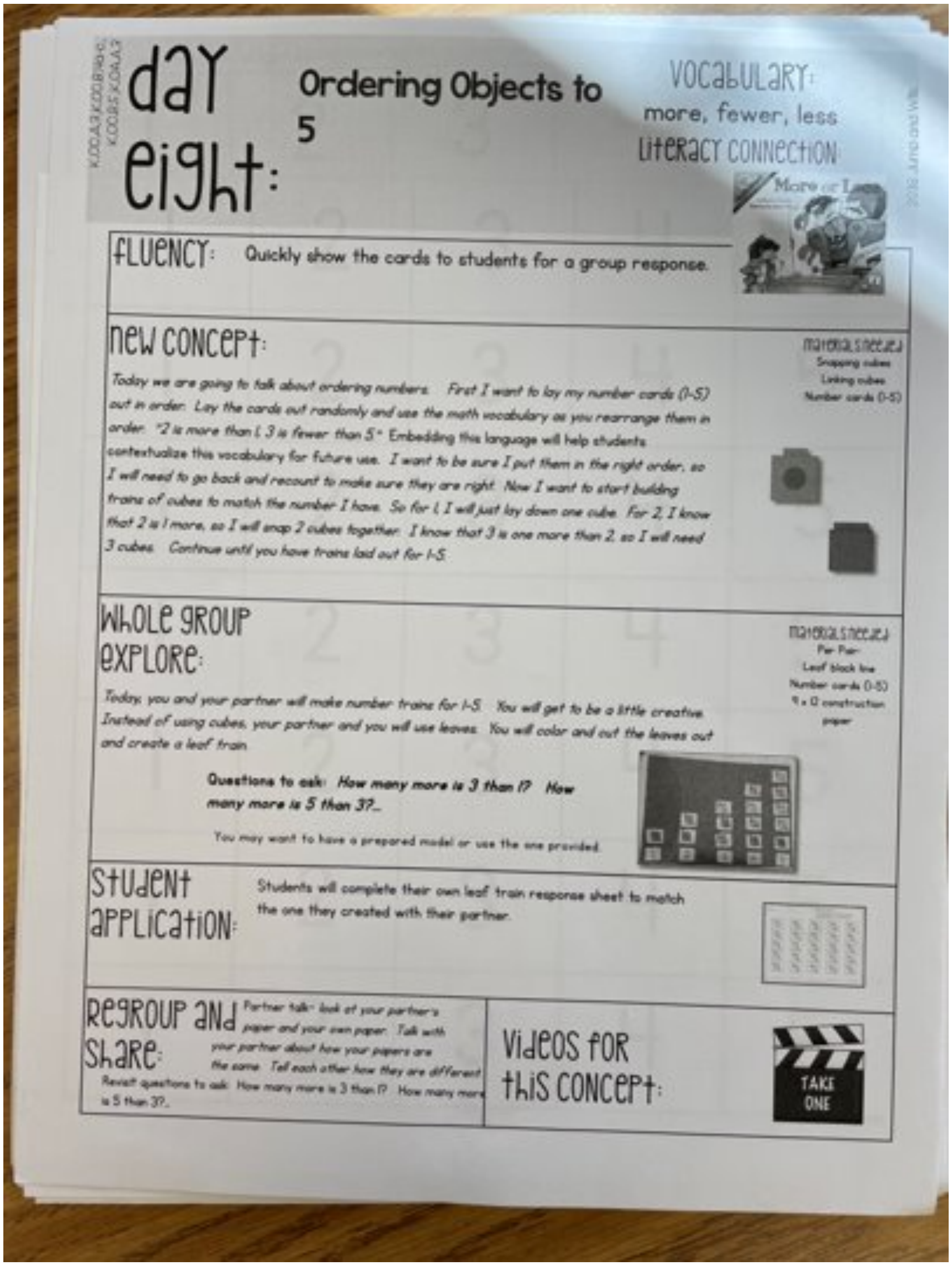
Appendix D

Example *enVisionMath* Lesson Plan



Appendix E

Example *Guiding Kinders* Lesson Plan (Jump & Willis, n.d.)



day eight: Ordering Objects to 5

VOCABULARY: more, fewer, less

LITERACY CONNECTION:

FLUENCY: Quickly show the cards to students for a group response.

NEW CONCEPT:

Today we are going to talk about ordering numbers. First I want to lay my number cards (1-5) out in order. Lay the cards out randomly and use the math vocabulary as you rearrange them in order. "2 is more than 1, 3 is fewer than 5." Embedding this language will help students contextualize this vocabulary for future use. I want to be sure I put them in the right order, so I will need to go back and recount to make sure they are right. Now I want to start building trains of cubes to match the number I have. So for 1, I will just lay down one cube. For 2, I know that 2 is 1 more, so I will snap 2 cubes together. I know that 3 is one more than 2, so I will need 3 cubes. Continue until you have trains laid out for 1-5.

MATERIALS NEEDED: Snapping cubes, Linking cubes, Number cards (1-5)

WHOLE GROUP EXPLORE:

Today, you and your partner will make number trains for 1-5. You will get to be a little creative. Instead of using cubes, your partner and you will use leaves. You will color and cut the leaves out and create a leaf train.

Questions to ask: How many more is 3 than 1? How many more is 5 than 3?...

You may want to have a prepared model or use the one provided.

MATERIALS NEEDED: Per Pair- Leaf black line, Number cards (1-5), 9 x 12 construction paper

STUDENT APPLICATION: Students will complete their own leaf train response sheet to match the one they created with their partner.

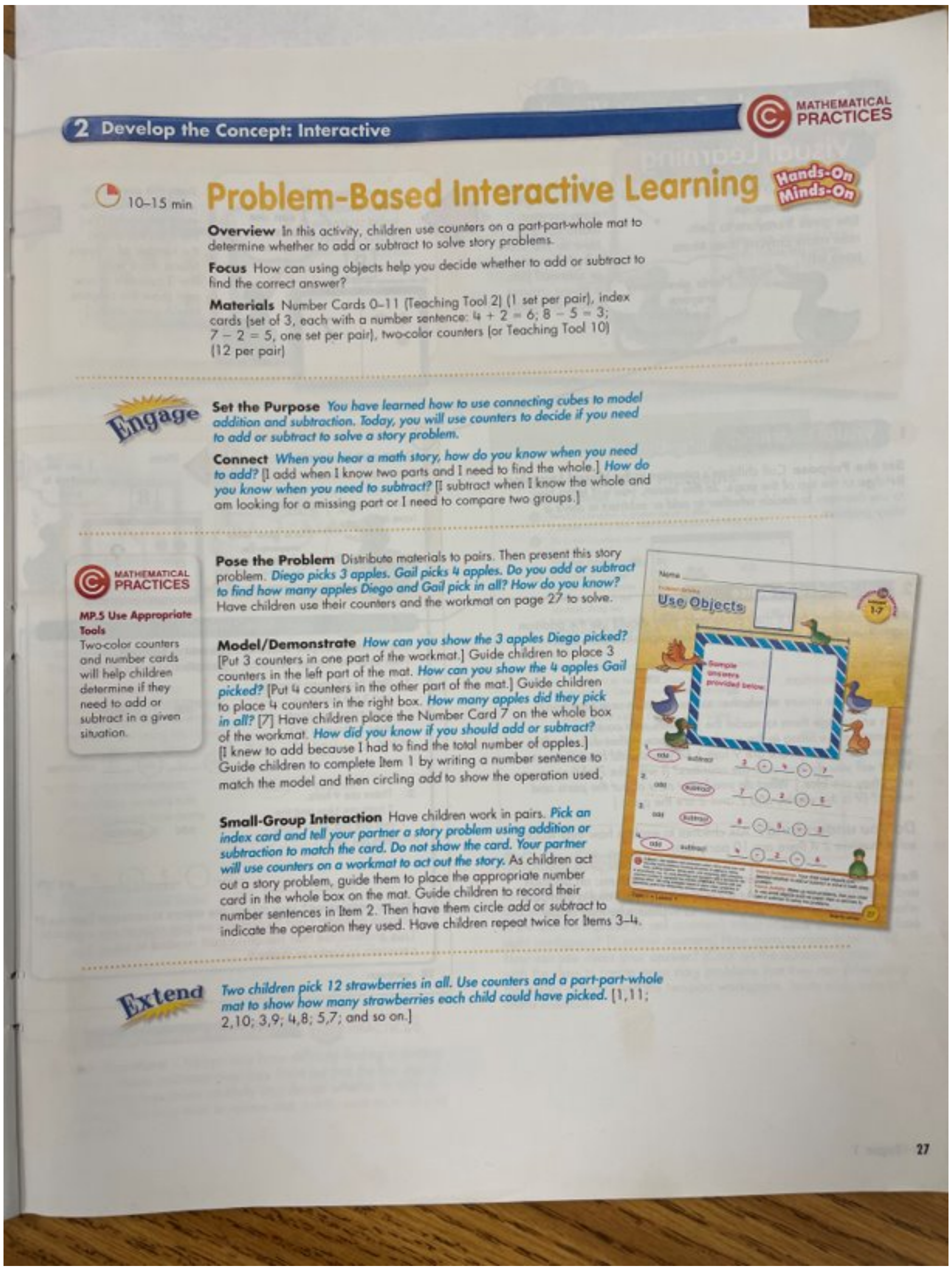
REGROUP AND SHARE: Partner talk- look at your partner's paper and your own paper. Talk with your partner about how your papers are the same. Tell each other how they are different. Revisit questions to ask: How many more is 3 than 1? How many more is 5 than 3?...

VIDEOS FOR THIS CONCEPT:

TAKE ONE

Appendix F

Problem-Based Interactive Learning Activity from *enVisionMath* Curriculum



2 Develop the Concept: Interactive

MATHEMATICAL PRACTICES

10–15 min **Problem-Based Interactive Learning** Hands-On Minds-On

Overview In this activity, children use counters on a part-part-whole mat to determine whether to add or subtract to solve story problems.

Focus How can using objects help you decide whether to add or subtract to find the correct answer?

Materials Number Cards 0–11 (Teaching Tool 2) (1 set per pair), index cards (set of 3, each with a number sentence: 4 + 2 = 6; 8 − 5 = 3; 7 − 2 = 5, one set per pair), two-color counters (or Teaching Tool 10) (12 per pair)

Engage

Set the Purpose *You have learned how to use connecting cubes to model addition and subtraction. Today, you will use counters to decide if you need to add or subtract to solve a story problem.*

Connect *When you hear a math story, how do you know when you need to add?* [I add when I know two parts and I need to find the whole.] *How do you know when you need to subtract?* [I subtract when I know the whole and am looking for a missing part or I need to compare two groups.]

MATHEMATICAL PRACTICES

MP.5 Use Appropriate Tools
Two-color counters and number cards will help children determine if they need to add or subtract in a given situation.

Pose the Problem Distribute materials to pairs. Then present this story problem. *Diego picks 3 apples. Gail picks 4 apples. Do you add or subtract to find how many apples Diego and Gail pick in all? How do you know?* Have children use their counters and the workmat on page 27 to solve.

Model/Demonstrate *How can you show the 3 apples Diego picked?* [Put 3 counters in one part of the workmat.] Guide children to place 3 counters in the left part of the mat. *How can you show the 4 apples Gail picked?* [Put 4 counters in the other part of the mat.] Guide children to place 4 counters in the right box. *How many apples did they pick in all?* [7] Have children place the Number Card 7 on the whole box of the workmat. *How did you know if you should add or subtract?* [I knew to add because I had to find the total number of apples.] Guide children to complete Item 1 by writing a number sentence to match the model and then circling *add* to show the operation used.

Small-Group Interaction Have children work in pairs. *Pick an index card and tell your partner a story problem using addition or subtraction to match the card. Do not show the card. Your partner will use counters on a workmat to act out the story.* As children act out a story problem, guide them to place the appropriate number card in the whole box on the mat. Guide children to record their number sentences in Item 2. Then have them circle *add* or *subtract* to indicate the operation they used. Have children repeat twice for Items 3–4.

Extend

Two children pick 12 strawberries in all. Use counters and a part-part-whole mat to show how many strawberries each child could have picked. [1,11; 2,10; 3,9; 4,8; 5,7; and so on.]

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Appendix G

MQI Overall Segment Codes[3]

Mathematical Quality of Instruction (MQI) 4-point

Overall Richness of the Mathematics			
This code captures the depth of the mathematics offered to students. Note: This is an overall code for each segment. It is not an average of the codes in this dimension, but an overall estimate of richness.			
Not Present	**Low**	**Mid**	**High**
Elements of richness are present but are all incorrect OR Elements of rich mathematics are not present.	Elements of rich mathematics are minimally present. Note that there may be isolated Mid scores in the codes of this dimension.	Elements of rich mathematics are more than minimally present but the overall richness of the segment does not rise to the level of a High. For example, a segment may be characterized by some Mid scores in the codes of this dimension or by an isolated High along with substantial procedural focus, etc.	Elements of rich mathematics are present, and either: a) There is a combination of elements that together saturate the segment with rich mathematics either through meaning or mathematical practices. OR b) There is truly outstanding performance in one or more of the elements.
Scoring Help - Overall Richness of the Mathematics			
In scoring Overall Richness, we assign a score of Not Present when there are no elements of richness present in the segment, or the components of richness that are present are all incorrect. For this code, we do not consider middling density of Mathematical Language to be an element of richness. That is, a segment could get a score of Low or Mid for Mathematical Language and still get a score of Not Present for Overall Richness.			

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Mathematical Quality of Instruction (MQI) 4-point

Overall Working with Students and Mathematics			
This code provides an overall evaluation of the teacher-student interactions around the content. Note: This is an overall code for each segment. It is not an average of the codes in this dimension, but an overall estimate of the teachers' interactions with the students around the content. If some portion of the response to students or remediation muddles the mathematics, the score may be adjusted downward.			
Not Present	**Low**	**Mid**	**High**
No or few interactions between teacher and students. There is no remediation and little use of student ideas OR Student mathematical contributions or difficulties occur, but teacher does not respond to or use those contributions. OR Teacher responses to student contributions are unclear or lead the segment off-track.	Teacher and students interact over content, but teacher responses are pro forma – moving instruction along with limited input from students. AND/OR There may be brief remediation.	Teacher and student interaction goes beyond pro forma exchanges to feature some use of student ideas, moderate conceptual remediation or extended procedural remediation. Portions of the clip may also feature a mix of strong and weak elements, or less-than-skillful use of student ideas.	Teacher weaves student ideas into the development of the mathematics and/or conceptually addresses misconceptions for clip. This must be done with some level of teacher skill at "hearing," understanding, and appropriately responding to student contributions or difficulties.

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Mathematical Quality of Instruction (MQI) 4-point

Overall Errors and Imprecision			
This code intends to capture the overall presence of teacher errors in doing and talking about mathematics. Note: This is an overall code for each segment. It is not an average of the codes in this dimension, but an overall estimate of the errors and imprecision in instruction.			
Not Present	**Low**	**Mid**	**High**
No errors occur. Do not score as Not present if Low, Mid or High is marked in any category above.	Small, momentary error(s) occur. For example, small slips in language, a brief lack of clarity, or a minor error in solving an exercise. These typically do not obscure the mathematics of the segment.	One or more errors, for example, persistent misuse of language, a lack of clarity in a portion of the segment and/or mathematical errors, but these typically obscure the math for part of the segment.	Either there are many small errors, a consistent lack of clarity, or one large error that obscures the mathematics of the segment.

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Mathematical Quality of Instruction (MQI) 4-point

Overall Common Core Aligned Student Practices			
This code attempts to capture evidence of students' involvement in "doing" mathematics and the extent to which students participate in and contribute to meaning-making and reasoning. • During ***active instruction segments***, this mainly occurs through student mathematical statements: reasoning, explanations, question-asking. • During ***small group/partner/individual work time***, this mainly occurs through work on a non-routine task. Note: This is an overall code for each segment. It is not an average of the codes in this dimension, but an overall estimate of the student participation in meaning-making and reasoning.			
Not Present	**Low**	**Mid**	**High**
There are no examples of student involvement in cognitively demanding classroom work. Tasks are largely procedural in nature or heavily scaffolded by the teacher. For example, there may be inquiry-response-evaluation-type teacher lectures with no examples of student explanation, questioning, or reasoning. Also score as Not Present if there are unproductive explorations in which *the majority* of the students are off-track mathematically.	There are few examples of student engagement in mathematical practices such as explanation, questioning, and reasoning. Tasks may be largely procedural in nature, but *occasional* student participation or a brief cognitively demanding task occurs.	Students engage with content at *mixed level*. Students may provide substantive explanations or ask mathematically motivated questions. This may also include tasks with variable enactment (high and then low during segment). This can also include instances in which some students/groups are engaged in tasks at a high level and others are not. Students may also engage in a task with middling cognitive demand.	Students contribute substantially to the building of mathematical ideas through posing questions, offering explanations, looking for patterns, making conjectures, and engaging in other types of reasoning. Such contributions are a major feature of the segment, with many student contributions or extended work on a cognitively demanding task.

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Appendix H

MQI Segment Codes[4]

Mathematical Quality of Instruction (MQI) 4-point

Students Communicate about the Mathematics of the Segment

This item captures the extent to which students communicate their mathematical ideas during the course of the segment, either in whole-group or small group settings. Examples of *substantive* student contributions include, but are not limited to, students presenting solution methods publicly (with or without words), asking mathematical questions, describing the meaning of a term, offering an explanation, discussing solution methods, commenting on the reasoning of others, etc.

In cases in which students are working in pairs or small groups, code substantive student contributions when you can a) hear them (e.g., a student and teacher are talking as teacher circulates, or you can overhear pairs of students) or b) the teacher's directions are very clear, and we can reasonably expect students to be having a substantive exchange for the duration of the small group work (e.g., a turn and talk). However, if it is not clear what students are talking about in small groups/pair work, score as Not Present.

Not Present	Low	Mid	High
Not present or minimally present. Students may contribute a word or phrase infrequently during whole-group instruction, but the segment primarily features teacher talk.	Student contributions are very brief. For example, students offer one- or two-word answers to questions or a partial description of steps, and they occur regularly during the segment.	There are some substantive student contributions, but these do not characterize the segment.	Substantive student contributions characterize the segment.

Scoring Help - Students Communicate About The Mathematics Of The Segment

Note that the difference between Not Present and Low is the prevalence of brief, one- or two-word answers, and the difference between Mid and High is the prevalence of *substantive* student contributions. The difference between Not Present/Low and Mid/High is whether there exist *any* substantive student contributions (i.e. a segment with a single substantive student contribution must be scored at least a Mid, and a segment with no substantive student contributions may not score above a Low). For instance, a student may provide one step of a procedure, followed by the teacher giving the next step. This would count as a Low. If the student narrates a complete set of steps for a problem, it would be counted as a Mid.

Student explanations and SMQR-type responses count here. In addition, this code encompasses additional types of substantive student contributions under Mid and High, including descriptions of choices students made while solving word problems, definitions, and so forth.

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Mathematical Quality of Instruction (MQI) 4-point

Task Cognitive Demand

This code captures student engagement in tasks in which they think deeply and reason about mathematics. This code refers to the *enactment* of the task, regardless of the initial demand of the curriculum/textbook task or how the teacher sets up the task for students.

Notes:

- Student confusion does not necessarily suggest that students are engaging with the content at a high cognitive level.
- Working on review tasks or on ideas discussed in previous lessons does not necessarily mean that students use lower order thinking skills.
- This code should not be confounded with the difficulty of the task or whether it is appropriate for a certain grade-level.
- Code a student presentation of a solution method at the same level of cognitive demand as the task itself was coded.

Not Present	Low	Mid	High
Students are engaged in cognitively undemanding activities. Examples of cognitively *undemanding* activities include: • Recalling and applying well-established procedures • Recalling or reproducing known facts, rules, or formulas • Listening to a teacher presentation with limited student input • Going over homework with little additional student work (e.g., reporting numerical answers) • Unsystematic exploration (i.e., students do not make *systematic and sustained progress in developing mathematical strategies or understanding*)	There is a brief example of a cognitively demanding activity, e.g. • A momentary think-pair-share where students define a term • Direct instruction with one or two examples of student explanations or SMQR • Tasks with a momentary high cognitive demand element • Tasks that are not completely routine, but are heavily scaffolded for students with hints or directions	Segment features mix of demanding and undemanding tasks and activities, e.g. • Tasks with variable enactment (e.g., demanding tasks followed by a transition to undemanding tasks; or, when working in small groups, some groups work on a high-demand task while some groups work on an undemanding task) • Direct instruction with student explanations and/or SMQR input at certain points • Tasks with middling cognitive demand	Students engage with content at a *high* level of cognitive demand. Examples of cognitively *demanding* activities include when students: • Determine the meaning of mathematical concepts, processes, or relationships • Draw connections among different representations or concepts • Make and test conjectures • Look for patterns • Examine constraints • Explain and justify

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Mathematical Quality of Instruction (MQI) 4-point

Students Work with Contextualized Problems			
Students work with contextualized problems (e.g., story problems, real-world applications, experiments that generate data). This includes solving such problems; discussing solutions to such problems; writing expressions or equations to represent contextualized situations; making sense of contextualized relationships through tables, graphs or other representations; or creating contextualized problems/situations to match expressions/equations. Note: Do not count when the teacher or student mentions a contextualized example for illustrative purposes (e.g., “you can think of 1/4 as a quarter and 1 whole as a dollar when you are converting fractions to decimals“ or “remember yesterday when we solved the hat problem?”), but the students do not work on it. Note: This is not a duration code; the difference between a Low, Mid, and High is amount of teacher scaffolding, not length. In the case of two or more different tasks with different levels, score to the highest level.			
Not Present	**Low**	**Mid**	**High**
Students do not work with contextualized problems or a contextualized problem is mentioned but not worked on.	The contextualized problems are executed as mostly rote/routine exercises. Teacher heavily scaffolds the presentation, for example, by telling students which procedure is to be applied, helping them write out the expression or equation, and so forth. Also include here times where there is data collection *without* reference to the underlying relationships or shape of the data. For instance, students may be collecting and marking down ice cream preferences in preparation for later plotting the graph and discussing.	Some student reasoning about contextualized problems is required for at least a portion of the problem execution; however, solution paths may be co-constructed or scaffolded by teacher to some extent. For instance: • Students play some role in deciding how to solve the problem • The problem starts off as non-routine but teacher hints at a solution method	Students are allowed significant opportunities to think and reason mathematically about contextualized problems. Students might need to choose which operation to apply, decide which kind of graph is appropriate for their data, or figure out how to write an expression that represents a pattern. The characterizing feature of this segment is that the teacher will not be doing much of the cognitive work of solving the problem.

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Appendix I

MQI Whole Lesson Code: Lesson is Mathematically Dense[5]

Mathematical Quality of Instruction (MQI) 4-point

WHOLE LESSON CODES

Lesson is Mathematically Dense				
This code captures the amount of mathematics – problems, tasks or concepts – worked on relative to the length of the lesson.				
Not at all true of this lesson **1**	**2**	**(Default Score)** **3**	**4**	**Very true of this lesson** **5**
The class does not get through many problems/tasks/concepts, and the reason was not "rich" or "cognitively demanding" explorations of the mathematics. Also score here for mathematically vacuous tasks (e.g. coloring, cutting, pasting).		Teacher and students work through a reasonable number of problems, or cover a reasonable number of mathematical topics. (Fewer topics or problems covered in reasonable depth can also count here.)		The class works through many problems or concepts; teacher covers a lot of mathematical ground. OR The class works on a few problems or concepts in meaningful ways. For instance, they may have had a long discussion of a conceptual student error to a problem, or done an extended exploration with many connections to the underlying mathematics, etc.

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Appendix J

Modification Flowchart