ABSTRACT

KATES, AMANDA JANE. Understanding Elementary Teachers' Mathematics-focused Professional Development Opportunities: A Mixed Methods Study. (Under the direction of Dr. Temple Walkowiak).

The purpose of this study is to provide the field information about elementary teachers' mathematics-focused professional development (PD) experiences. To do so, this study employed a mixed-methods two-phase sequential explanatory design. In Phase 1, the quantitative component, a web-based survey was used to collect data from 174 elementary teachers working in the same school district. Using the results of the analyses from Phase 1, two schools were purposefully selected for Phase 2 of the study. Phase 2 consisted of semi-structured interviews with the school leaders (i.e., principal, assistant principal, instructional coach) and document analyses of the school's improvement plan. The results are presented in two articles.

The first article uses the quantitative data to examine PD opportunities from the teachers' perspectives. The results show that teachers participated in different types of PD and some of their opportunities included collaborative activities that focused on mathematics content and pedagogy. Moreover, there was significant variation between teachers' experiences.

The second article uses the qualitative data to examine the embedded PD opportunities teachers are provided at two different schools. Results show that teachers' embedded opportunities are influenced by the principals' leadership style and the school-based decisions around resources, schedules, and the role of the instructional coach.

Understanding Elementary Teachers' Mathematics-focused Professional Development Opportunities: A Mixed Methods Study.

by
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DEDICATION

This dissertation is dedicated to:

My best supporter, my mom;

My favorite teachers, my students;

My greatest accomplishment, my children; and

My happiest surprise and one true love, my husband.

BIOGRAPHY

Amanda Jane Kates was born and grew up in Oswego, New York, and lived there with her parents and two brothers. Amanda credits her high school teacher, Mr. Paul Muench, as her reason for pursuing a career in education. Until she met Mr. Muench during her senior year of high school, Amanda was convinced that school was not for her and considered herself an unmotivated struggling student and perceived that her teachers felt the same. She felt especially helpless when it came to mathematics. Amanda remembers finding it impossible to memorize multiplication facts in elementary school, which was always made public by her name never being on the class bulletin boards highlighting the "smart" students that passed all of their timed multiplication tests.

Later during high school, Amanda's work was displayed for others to see in her 9th-grade mathematics class where her teacher chose to recognize students' failing assignments and incomplete homework by hanging them on the bulletin board. It was then that Amanda knew she wasn't a mathematics person; she wasn't much of a school person either. That was until the first day in her "Participation in Government" class during her last semester of high school. She had no idea that the teacher of that class was about to influence the course of her entire life. She immediately recognized that Mr. Muench was different because he treated her like she was smart. In fact, Amanda noticed that he treated all students like they were smart. She recalled the day Mr. Muench said something that changed her self-perception forever. He said, "Your passion is going to change the world. I can't wait to see what you accomplish." At that moment, she had an epiphany. She was destined to be a teacher.

By chance, Amanda became an elementary mathematics teacher. She did not consider herself prepared but thought it must be pretty easy to teach elementary mathematics, but she was wrong! However, she tried, and before each lesson, she remembered how influential a teacher's words can be and vowed to remember that no matter the situation. A few years later, Amanda took advantage of a district partnership between her school district and North Carolina State University. The program was led by two incredible professors, Dr. Temple Walkowiak and Dr. Valerie Falkner. It was through their teaching and mentorship that Amanda completed the program and did meaningful work as an elementary mathematics specialist. It was also the influence of Dr. Walkowiak and Dr. Falkner that led Amanda to later apply to the Ph.D. program, where they both continued to challenge Amanda's thinking while also taking the role of caring mentors.

Mr. Muench believed Amanda's passion would change the world, so she continues to believe it herself as she advocates for quality and equitable public schools. The lessons that she learned from her experiences as a student, teacher, instructional coach, and mom are the motivating force that drives her commitment to supporting educators and students with teaching and learning mathematics.

ACKNOWLEDGMENTS

I am grateful for my dream team committee that guided this work. To my advisor and committee chair, Dr. Temple Walkowiak, you are a mix of kindness, thoughtfulness, brilliance, and humility. I appreciate you more than I tell you. To the members of my committee, Dr. Valerie Faulkner, Dr. Sarah Carrier, and Dr. Lee Stiff. Thank you for pushing me always to think harder.

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CHAPTER 1: INTRODUCTION

Federal policies set the expectation of a better education for all American students by increasing the accountability of schools. The No Child Left Behind Act of 2002 required states to determine common grade-level standards that would prepare all students for college or career. As the Common Core State Standards for Mathematics (CCSS-M) were released in 2010, federal funds were offered to states choosing to adopt these standards. According to the Common Core States Standards Initiative, by 2013, forty-one states, the District of Columbia, and four US territories had adopted the CCSS for English Language Arts and Mathematics.

The CCSS-M set expectations for the content and skills students should master by the end of each grade and the practices which they should use regularly, but these standards do not include directions on how to teach to meet these expectations. The mathematical practices for students (e.g., model with mathematics), in particular, have implied that instruction should move from teacher-directed to student-centered instruction. To successfully provide this type of instruction, teachers need to have a deep understanding of both the content and how students understand and learn the material (Ball, 2003; Clements & Sarama, 2004; Carpenter, Fennema, Peterson, Chiang & Loef, 1989). The National Council of Teachers of Mathematics (2014) supported the creation and implementation of the CCSS-M but they, along with mathematics education researchers, acknowledged that the shift would take time (e.g., Hirsch, Lappan, & Reys, 2012). This implies that the implementation of the new Standards would require focused training as well as time for teachers to develop new instructional strategies.

Teacher Professional Development

Professional development (PD) provides in-service teachers with opportunities to develop their practice. Traditional PD often extracts teachers from their classrooms to attend a workshop about a learning or teaching theory. However, these types of disconnected experiences are often ineffective (Archibald, Coggshall, Croft, & Goe, 2011; Little, 1993; Stein, Smith & Silver, 1999; Hargreaves, 2000). In other words, the new information is not associated with teachers' actual day to day work; therefore, the PD does not typically change what teachers are doing. Researchers have called for a more situated design to PD connected to the content and practice of teaching (Darling-Hammond & McLaughlin, 1995; Putman & Borko, 2000; Knapp, 2003; Desimone, 2009). Instead of PD being thought of as information for teachers to know, a situated design considers the context in which they work. For example, PD for teachers working in schools with a large population of English Language Learners would consider the particular needs of the student population. There seems to be a consensus in the field around shared design features of effective PD. The work of Darling-Hammond, Hyler, and Gardner (2017) is often cited as it defines these features. The authors state effective PD (1) is content-focused; (2) includes active learning; (3) gives participants opportunities to collaborate; (4) incorporates models of effective practice; (5) provides coaching or other expertise on instruction; (6) includes constructive feedback and opportunities to reflect on teaching; and (7) is sustained in duration with multiple experiences in the target area.

Significance of the Study

Policies support professional growth by mandating and funding states to provide "high-quality" PD for teachers. It has been estimated that $20 billion of local, state, and national funds are spent on PD each year (Guskey & Yoon, 2009). Researchers make recommendations utilizing effective design features (Darling-Hammond & McLaughlin, 1995; Desimone, 2009; Knapp, 2003; Putman & Borko, 2000), little is known about most teachers' PD experiences. Sztajn (2011) explained researchers have limited information about what is happening because the majority of PD is locally planned and implemented. This means that data from large-scale surveys only provide some information about teacher PD. For example, the National Staff Development Council (2009) reported that most teachers surveyed participated in PD. However, the authors say experiences vary between schools and typically do not include "the kind of job-embedded collaborative learning that has been found to be important in promoting instructional improvement and student achievement" (p. 25). It could be that PD is changing as more recent research suggests PD is moving away from one-time workshops that are isolated (Desimone & Garet, 2015). Although both pieces of information are valuable, there is still missing information. For instance, it could be that elementary teachers are only participating in PD focused on their reading instruction. This study seeks to understand teachers' learning opportunities and provide the field missing information about PD experiences specific to mathematics.

Research Questions

The purpose of this study is to understand elementary teachers' mathematics-focused PD experiences by examining the opportunities of teachers working in the same district. The following research questions guide this study.

1) From the perspective of elementary school teachers working in the same district, in which mathematics-focused learning opportunities do teachers engage?
2) What is the relationship between mathematics-focused learning opportunities and other factors (e.g., grade level, years of experience, school contextual factors)?
3) What additional information can school documents and interviews with school leaders provide when trying to understand the relationship between school context and teachers' embedded learning opportunities?

Definition of Terms

For the purpose of clarity, the following definitions are provided.

1. *Professional Development* (PD), *Training, Learning Opportunities, Learning Experiences* will used interchangeably in this research to discuss teachers' learning opportunities.
2. *Facilitator* will be used to describe teacher educators and trainers that lead PD.
3. *Mathematics Coach*, *Instructional Coach, Coach* will be used interchangeably to discuss school-based curriculum coaches that support teachers with mathematics instruction.
4. *Standards* refer specifically to Common Core Standards for Mathematics (CCSS-M) or other standards that were created to align with CCSS-M. In other words, standards that set goals and expectations of the skills and knowledge students need by the end of each grade in order to be college or career ready by high school graduation.
5. *Standards-based Instruction* refer to the teaching practices published in NCTM's (2014) *Principles to Action: Ensuring Mathematical Success for All*. The practices are: (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; and (8) Elicit and use evidence of student thinking.
6. *Student Centered Instruction* is instruction in which students have opportunities to develop conceptual understanding of content and their ideas and thinking are used to move the lesson forward.
7. *Curriculum* is the mathematics content aligned with the Standards.

8. *Pacing Guides* are like a calendar that indicates the order in which mathematics topics are taught. It may also tell how many instructional days to spend on each topic. Teachers might be provided with a pacing guide, create their own pacing guide, or use a pacing guide developed by researchers or resource providers.
9. *Lesson Plan Resources* are schools provided lesson plans to teach mathematics. Examples include textbooks, online resources, and district created lesson plans.
10. *Digital Resources* provide mathematics instruction through videos and game-like environments. This means a student receives instruction from the resource. Examples include IXL, Splash Math, iReady, Accelerated Math, and Zearn Math.
11. *Math Manipulatives* are physical tools that help students understand mathematics concepts such as connecting cubes, fraction circles, pattern blocks, or base-ten blocks.
12. *School Context* refers to school characteristics such as the geographical location, demographics of the students, teachers, and administrators, and available resources.
13. *School Leaders* refer to school personnel with leadership roles (e.g. principals, assistant principals, curriculum experts).
14. *Professional Learning Communities* (PLCs) are organized groups of teachers that work collaboratively to improve teaching and learning at the school.
15. *Grade-level PLC meetings* involve teachers from the same grade level. For example, all the first-grade teachers attend the first-grade PLC meeting.
16. *Vertical PLC meetings* involve teachers from multiple grade levels. For example, a vertical PLC might include one teacher from each grade level in the school.

17. *Planning Period* is provided time to plan lessons, prepare materials, collaborate with other teachers, and communicate with parents. During this time, teachers are not responsible for students.

Outline of the Dissertation

The dissertation presents the research in two research papers organized in six chapters. Chapter One provides an introduction and focus of the study. Chapter 2 reviews the literature and then describes how the literature informed the development of the Teachers Learning Opportunities in Mathematics Survey (TLO-M). Chapter 3 outlines the methodology which includes information about the TLO-M validation process and description of the participants, context, and plan for how the data will be analyzed. Chapters 4 and 5 consists of two journal articles that will be submitted for publication. The first two research questions are answered in the Chapter 4 article and the first and third research questions are answered in the Chapter 5 article. Finally, Chapter 6 will conclude with a summary of findings and implications for further research. It is important to note that information from the literature review repeats in Chapters 4 and 5 due to the results being presented in two papers.

CHAPTER 2: LITERATURE REVIEW

This chapter first reviews theoretical frameworks that consider the need for elementary teachers' mathematics-focused PD as well as the type of PD that is recommended. Considering the purpose of this study is to understand elementary teachers' opportunities to engage in mathematics focused PD, there was a need to create a measure. Therefore, the second part of this chapter will discuss the creation of the Teacher Learning Opportunities-Mathematics (TLO-M) survey which quantifies such opportunities. The components of the TLO-M are described and connected to both theoretical and empirical research. The chapter concludes with details about the TLO-M item development.

Shifting Mathematics Instruction

Principles to Actions: Ensuring Mathematical Success for All, released by the National Council of Teachers of Mathematics (NCTM) in 2014, explains the historical context and the vision of common Standards as a way to improve mathematics education for all students. Equally important, the book illustrates the shift in the expectation of mathematics instruction by introducing the Eight Mathematics Teaching Practices (MTP) (See Figure 2.1). This framework represents "the core set of high-leverage practices and essential teaching skills necessary to promote deep learning of mathematics" (NCTM, 2014, p.9). Essentially the framework exemplifies effective teaching and can be used to support progress toward providing instruction that meets the expectations of the Standards.

Admittedly, the MTPs are considerably different than traditional instructional methods (i.e., students taking or copying notes presented by teacher, teachers showing students steps for generating solutions). For that reason, NCTM (2014) recognized that a shift in instructional methods to be more aligned with the MTPs will take time and training. Acknowledging the significance of an instructional shift is not new. In 2001, the National Research Council stated, "Our view of mathematics proficiency requires teachers to act in new ways and to have an understanding that they were once not required to have. In particular, it is not a teacher's fault that he or she does not know enough to teach in the way we are asking" (2001, p. 428). This means the expectations of instruction are much different than before; therefore, PD is a crucial component of implementing Standards-based instruction.

Mathematics Teaching Practices

(NCTM,2014)

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.

Figure 2.1. Mathematics teaching practices (NCTM, 2014).

Mathematical Knowledge for Teaching

With the agreement that PD will support teachers' shift in instruction, researchers from the University of Michigan worked on defining the special knowledge needed to teach student-centered mathematics (Ball, Thames & Phelps, 2008). The team studied teachers in their classrooms to understand the different ways teachers use mathematics throughout the day. From their work, they created a framework to exemplify different types of mathematics knowledge needed to teach. The Mathematical Knowledge for Teaching (MKT) framework (See Figure 2.2) includes four domains that include subject and pedagogical knowledge. Although each domain is defined as something different than the others, the authors acknowledge grey area. This means that some teaching activities may not sort neatly into one category resulting in differences in interpretation. A definition and example of each domain follows.

1) Common Content Knowledge (CCK) is considered typical because it is not specific to the work of a teacher. This domain includes things like understanding how to solve mathematics problems and using correct notation and terms. For example, a teacher uses mathematics to calculate the cost of admission to an amusement park for all of the students and teachers in third grade.
2) Specialized Content Knowledge (SCK) is understanding how concepts are decomposed for developing students' understanding. For example, a teacher introduces multiplication to third grade students by having them think of things that come in pairs.
3) Knowledge of Content and Students (KCS) is using SCK to understand the students in the class. Examples of KCS include anticipating how students would solve a problem, identifying what might be difficult about a problem, choosing appropriate tasks for students that are aligned with mathematical goals, and making sense of student thinking. For example, a teacher differentiates a multiplication task by modifying the numbers. In this case, some students will be multiplying two-digits by one-digit and others will be multiplying two-digits by multiples of ten.
4) Knowledge of Content and Teaching (KCT) is understanding how to teach the content best. Examples of KCT include designing a lesson to ensure mathematical coherence, providing scaffolding to support students' understanding of the mathematics, and choosing the most effective representations for the task or target mathematical concept. For example, when teaching multiplication, a teacher might demonstrate their KCS by

using an area model to support students' to make sense of the distributive property.

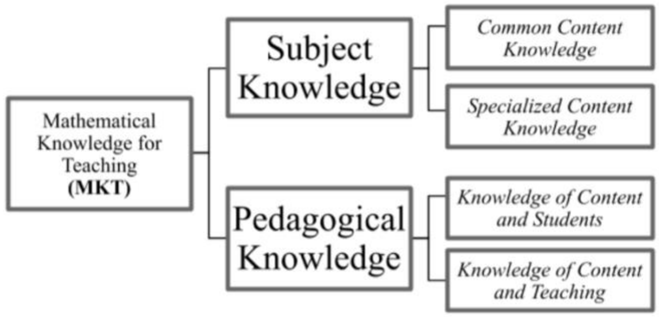


Figure 2.2. The domains of mathematical knowledge for teaching (Ball et al., 2008).

The authors recognized the difficultly in simplifying something so complex and continue to refine their ideas. Figure 2.3 shows additional categories the authors are exploring. These include an awareness of how mathematics topics are related (*Horizon Content Knowledge*) and represented in the curriculum (*Knowledge of Content and Curriculum*). For example, a first-grade teacher understanding how decomposing numbers connects to subtraction strategies used in later grades. The team is less concerned with the domain names and particular definitions because the importance of the work is to demonstrate the complicated nature of teaching. Ball and Forzani (2009) argued that "Most adults do not naturally develop the ability to perform the tasks required of teachers. And, the special knowledge, skills, and orientations that underlie and enable the work of teaching are not typically mere by-products of intelligence or academic talent or success" (p. 500). Therefore, like any highly skilled professionals, teachers will need quality training to develop this specialized knowledge (Ball, Thames, & Phelps, 2008; National Research Council, 2001).

In attempt to measure MKT, the University of Michigan team created the Content Knowledge for Teaching Mathematics Measures (MKT Measures; Hill, Schilling, & Ball, 2004). The authors state that creating items helped refine their ideas about what knowledge is needed to teach mathematics. Additionally, the study found significant relationship between MKT and student achievement. This suggests developing a teacher's MKT would result with higher student achievement scores. However, the authors acknowledge that MKT is difficult to measure. In the same way, Fauskanger (2015) used a combination of multiple-choice questions and open responses to conclude that MKT might not be able to be captured with multiple choice questions. For instance, she found some correct multiple-choice items were followed with a confusing open response. Likewise, some incorrect multiple-choice items were followed with open responses that demonstrated understanding.

Although future adjustments may improve the assessment, the MKT Measures are validated tools used to support claims that developing MKT is worthwhile. For example, the MKT Measures have been used to link MKT to quality of instruction. Hill, Umland, Litke, and Kapitula (2012) found a significant relationship between MKT and the mathematical accuracy of teachers' explanations. This means teachers with higher MKT scores demonstrated a better understanding of the mathematics concepts than teachers with lower MKT scores. Although the authors observed frequent errors in the explanations of teachers with lower MKT, there was not a significant difference in how this group engaged students. In other words, the MKT score did not relate to student participation. The authors explained this by suggesting that the Standards-aligned curriculum could be helping teachers with lower MKT to provide better instruction. The findings align with previous research that found instructional practices were influenced by the availability of resources (Hill et al., 2008). In comparison, Munter and Correnti (2017) found that teachers' MKT scores impacted how students participated in lessons. Teachers with higher MKT scores facilitated lessons with greater cognitive demand when compared to the lessons of teachers with lower MKT scores. The authors reported that teachers with high MKT were able to facilitate problem solving tasks and use student ideas to guide discussions. Collectively, these articles provide evidence that teachers with a deeper understanding of content and pedagogy (determined by the MKT Measures) may provide better mathematics instruction.

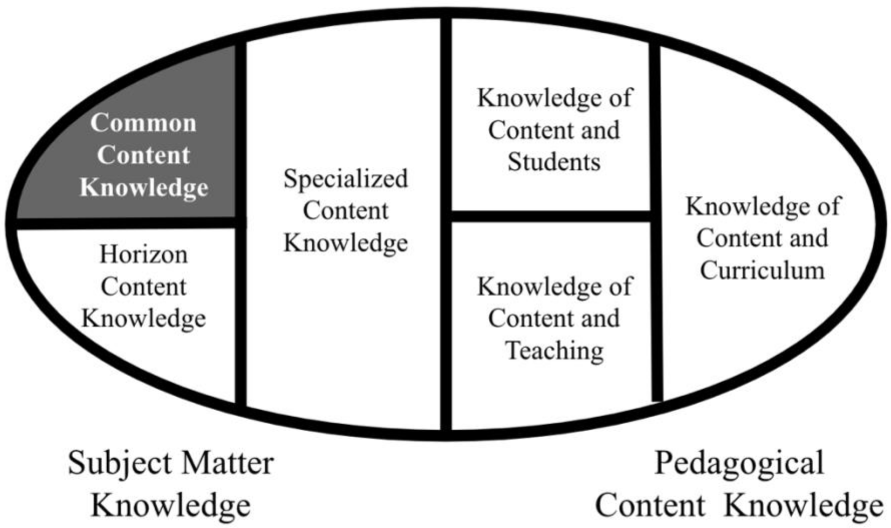


Figure 2.3. Additional MKT domains (adapted from Ball, Thames & Phelps, 2008).

The Eight Mathematics Teaching Practices (NCTM, 2014) and the Mathematical Knowledge for Teaching frameworks (Ball, Thames & Phelps, 2008) justify the importance of mathematics-focused PD. First, the expectations of teaching have changed, and teachers need PD in order to understand new expectations. Second, the knowledge to provide this type of instruction is not common and requires specialized training. The next section of this chapter considers what research says about implementing successful PD.

Features of Effective Professional Development

Although there is an abundance of research on PD, the outcomes are difficult to compare because the field lacks common measures and reporting guidelines (Desimone, 2009; Sztajn, 2011). Some may add that many studies are not rigorous enough to compare. For instance, self-reports are sometimes considered too subjective to determine the effect PD had on knowledge or instruction. Yoon, Duncan, Lee, Scarloss, and Shapley (2007) determined that only nine of the

1,300 possible studies identified could be used to determine the effect of PD on student achievement. This report echoed the inconsistencies in measures that Guskey (2003) previously reported. That is, Guskey articulated how researchers used different terminology and measures to define and evaluate PD. Desimone (2009) agreed and noted the numerous experiences all under the same PD umbrella. For instance, informal conversations between teachers and attending a mathematics conference are both considered PD. For that reason, she argues, PD is difficult to measure and suggested the field adopt a common framework to evaluate PD which includes details about the context and core features of the PD (e.g., content focus, active learning, coherence).

Although there is not an established system that compares features of PD for evaluation, over the past two decades, there is a general consensus about the shared features of effective PD as indicated by positive teacher or student outcomes (Putman & Borko, 2000; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Desimone, 2009; Garet, Porter, Desimone, Birman, and Yoon, 2001). For example, Garet, Porter, Desimone, Birman, and Yoon (2001) determined that PD that included active engagement around content was more likely to influence teachers' instruction. Darling-Hammond and colleagues (2009) used the previously mentioned study and several others to create a list of common features of effective PD. This does not mean that effective PD shared all the same features. Instead, effective PD was found to have a combination of some features. The authors used the studies to define and exemplify "a new paradigm" of teacher learning that moves away from traditional disconnect experiences to learning communities engaged in inquiry around practice. Based on the findings, they created a list of seven features of effective professional development.

Darling-Hammond, Hyler, and Gardner (2017) further developed these ideas by examining the PD features found in additional empirical studies. The authors propose several ideas to support school leaders' PD decisions which can be found in the 2017 report *Effective Teacher Professional Development.* The recommendations include using the features as well as teachers' feedback to ensure PD is connected to practice and addresses the needs of the school. One suggestion reads, "States, districts, and schools could regularly conduct needs assessments using data from staff surveys to identify areas of professional learning most needed and desired by educators" (p.23). On the other hand, this might not be the best advice when determining mathematics PD for elementary teachers. Desimone, Smith, and Ueno (2006) recommended that school leaders disregard teacher choice after finding that the least prepared teachers participated in the least amount of mathematics focused PD. From the study, the authors concluded that teachers with a mathematics background choose to participate in more sustainable PD than teachers lacking a mathematics background. For this reason, school leaders might need to consider additional information when making decisions around PD focused on mathematics.

Next I will use the seven features of effective PD (Darling-Hammond et al., 2017) to elaborate on why special considerations might be necessary when deciding on mathematics focused PD; first by defining the feature and then by presenting information to consider.

1) Content Focused: PD should focus on content that is directly related to the teachers' work, usually being subject-specific and job-embedded. PD should also align with school and district goals. Now consider that teachers might not have been provided with adequate opportunities to understand the difference between Standards-aligned and traditional instruction. Therefore, teachers might not see the need to attend PD. For this reason, it could be beneficial to know how teachers perceive the expectations set by Standards.

2) Active Learning: PD should be inquiry based and connect to teachers' experiences. Moreover, PD should provide opportunities for teachers to make sense of and reflect upon new information. Now consider that teachers' prior experience with mathematics were probably very traditional. For that reason, PD might not connect to their experiences. Therefore, it might be beneficial for PD to contradict traditional beliefs and support teachers in shifting how they think about mathematics teaching and learning.
3) Collaboration: PD should be collaborative and provide opportunities to share ideas. This typically occurs in embedded situations such as coaching, informal conversations, and team meetings. Now consider that the ideas teachers share will be related to their experiences. This means teachers could be sharing ideas and resources that would not support the shift to Standards-aligned instruction. For this reason, it might be beneficial to have a mathematics specialist lead teachers' conversation (also suggested by feature number six: coaching and expert support).
5) Models of Effective Practice: PD should illustrate effective instruction with high-quality resources (i.e., Standards-aligned materials) as well as by providing opportunities to observe instructional methods (i.e., watching someone else teach). Now consider that shifting instruction is a process that will take time. Therefore, providing a model one or two times will probably not be enough (also suggested by feature number eight: duration).
6) Coaching and Expert Support: PD should be facilitated by a coach or expert. For instance, a researcher provides a series of workshops for a school district or a school-based coach uses questions to guide PLC conversations. Now consider that the coach will need to have expert knowledge of mathematics as well as how teachers learn to teach

mathematics. This means a curriculum coach that specializes in literacy instruction might not be able to provide coaching that will shift teachers' mathematics instruction.

7) Feedback and Reflection: PD should provide opportunities for feedback and reflection. Although feedback and reflection are two separate activities, they are grouped as one feature because of the influence they can have on teacher learning when used together (Darling-Hammond et al., 2017). This means teachers should have opportunities to think about and make changes to their instruction after receiving feedback. Now consider that school leaders need to understand the expectations of Standards-aligned instruction in order to provide useful feedback.
8) Duration: PD needs to span over time and provide multiple opportunities to focus on one concept. Research shows effective PD has at least 20 hours of contact time (Desimone, 2009) and spans over weeks, months, or even years. Common models include embedded PD that happens during PLC meetings and external PD that incorporates an intensive period during the summer and continued support throughout the school year. Now consider teachers are not only being asked to change how they teach but also change their beliefs about mathematics. For this reason, 20 hours of PD during one school year is probably not enough.

The features of effective PD (Darling-Hammond et al., 2017) can be a useful resource when making decisions around PD. However, as demonstrated, thinking about PD focused on mathematics might require additional attention. Thus far, this chapter introduced frameworks that support the need for mathematics focused PD and a framework that support effective PD design. Separately each provides useful information but considering that mathematics PD might require special considerations, the frameworks might be more beneficial in explaining teacher

PD if considered together. Next the literature specific to mathematics PD will be presented and then connected to the components of the TLO-M.

Types of Professional Development

Darling-Hammond, Hyler, and Gardner (2017) call for PD to shift from external one-shot workshops to an embedded design that situates the learning opportunity in the teachers' work. Using this explanation, embedded PD could be thought of as experiences are integrated into daily practice (e.g., team planning) while external opportunities are not (e.g., workshops or conferences). However, when attempting to sort the PD literature, some learning experiences did not seem to fit into either category, particularly learning opportunities that had no connection to a school. For example, teachers supporting one another via social media typically occurs outside of the school day. This prompted a new category which I call self-directed PD. The literature provided evidence that PD can be sorted into the following three types. (1) Embedded PD is part of a teacher's normal routine. This means the learning experience is ongoing and occurs at the school. (2) External PD is outside of the normal routine. This means it happens away from the school. The frequency of sessions ranges from one to many. (3) Self-directed PD can happen during or outside the workday and is thought of as activities a teacher participates on her own. When classifying PD by type, there was additional evidence that the type PD could be further sorted by events. For instance, as shown in Figure 2.4, teacher PD can be sorted in three types (embedded, external, self-directed) and further defined by event (e.g., planning period, PLCs, coaching). A description of types and events follows.

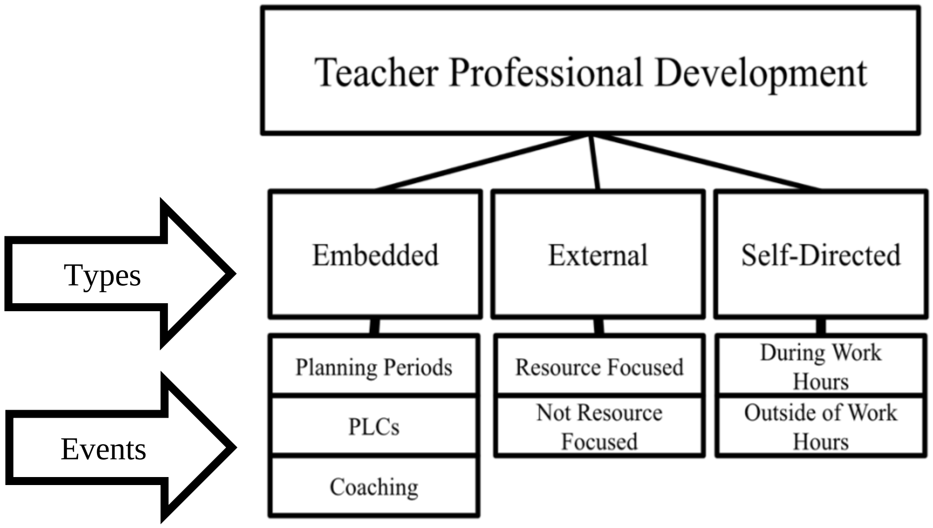


Figure 2.4. *Types of professional development.*

Embedded PD

Embedded PD occurs during the typical school day. There is evidence in the literature, as described below, of embedded PD taking place during shared planning periods, while meetings with Professional Learning Communities (PLC), and while being coached.

***Shared planning periods*.** Many elementary teachers have a planning period built into their daily schedules (NCES, 2012). This provides time to address responsibilities such as preparing for lessons and communicating with parents. Sometimes planning periods are used to collaborate with other teachers. In a systematic review of the literature, Vangrieken, Dochy, Raes, and Kyndt (2015) concluded that opportunities to collaborate could have positive impacts such as reducing teacher isolation and increasing teacher motivation and efficacy. Although teachers might not have the recommended ten hours per week (Wei, Darling-Hammond, Andree, Richardson, and Orphanos, 2009), there is evidence that teachers are provided time to work together. Using a national sample of 3,328 public school teachers, Rentner, Kober, Frizzell, and Ferguson (2016) reported that most teachers have opportunities to collaborate with others that teach the same grade-level or content. However, the same teachers think additional planning and collaboration time would improve their day-to-day work. Similarly, in a study seeking to understand co-teaching, Fennick and Liddy (2001) found that many special education and classroom teachers responsible for co-teaching are not provided enough joint planning time.

Providing teachers with planning time might be especially beneficial to novice teachers (Wood & Weasmer, 2004). In one example, Bauml (2014) reported that collaborating with other teachers during the planning period had positive effects on a new teacher's mathematics instruction. The author said the teacher used the time to ask her teammates questions about school procedures and materials (e.g., testing, pacing guide) as well as questions about instruction (e.g., how to teach). The teacher credited the support she had during this time to her success with mathematics instruction.

Professional learning communities. Professional Learning Communities (PLC), sometimes called Professional Learning Teams (PLT), also provide teachers time to collaborate. According to DuFour and DuFour (2013), there are specific characteristics that differentiate PLC meetings from other situations in which teachers work together. Specifically, PLCs imply a collegial setting where teachers focus on specific goals to improve student learning. This means PLC meetings are much more intentional than a casual conversation around mathematics. The idea of teachers learning in this type of environment is not exclusive to PLCs. For instance, Wegner (1998) described situated learning that happens in communities of practice. In the case of teaching, this would mean teachers improve their instruction by meeting with other teachers to discuss their practices. For instance, this might happen when teachers engage in a lesson study which includes planning together, observing each other teach, and reflecting together. Critical

Friend groups are another method used to develop teaching practice through collaboration by teachers helping each other develop solutions for their problems (Darling-Hammond & McLaughlin, 1995). When examining teachers participating in critical friend groups, Kuh (2014) reported that one teacher would share a problem and then receive advice from the others. The author concluded that using a protocol to guide the discussions kept conversations focused on practice and student learning.

Likewise, the work of a PLC is guided by student learning and is described as an innovative environment where teachers work together to develop instructional strategies that will meet the needs of their students (DuFour & DuFour, 2013). For example, after noticing many students are unable to explain how to compare fractions on a common formative assessment, the teachers in the 4th grade PLC decide how they will teach benchmark fractions. After trying out the activity with each of their classes, the group reflects on what happened and what needs to be done next. To foster this type of collaboration, schools should have supportive and shared leadership and have common values and vision (Hord & Sommers, 2008). This means teachers need to be comfortable enough to provide each other with constructive feedback and have the authority to make decisions about instruction. It is likely that some PLCs function better than others. For instance, Nickerson and Moriarty (2015) concluded that teachers that get along were more likely to work towards school-wide goals. In addition, experienced teachers have deeper conversations and focus more on student learning than novice teachers (Horn & Kane, 2015). This could mean personalities and experience of staff members influence how much learning occurs during PLC meetings. Regardless of the differences, PLCs have been noted as the most effective type of PD (DuFour & DuFour, 2013).

Coaching. In 2006, then NCTM president Skip Fennell urged schools to provide teachers with the support they need by hiring school-based mathematics specialists [coaches]. The research generated since 2006 supports his claim (Campbell & Malkus, 2011; Hopkins, Ozimek, & Sweet, 2017). In one study, Campbell and Malkus (2011) determined that three years of coaching had a significant impact on student achievement. However, other studies have mixed results. For example, Stein and Kaufman (2010) determined that coaching was more effective when the coach engaged teachers in conversations around mathematical concepts and student learning. More specifically, the coaches that only supported teachers with material management did not influence a change in instruction. Other research also provides evidence that coaching experiences are likely to vary. Mudzimiri, Burroughs, Luebeck, Sutton, and Yopp (2014) reported on how several coaches spent their day, verifying the variation of activities across coaches. Activities included meeting with teachers to plan instruction, providing a teacher with feedback, creating materials for teachers to use, and showing a teacher how to use learning apps for tablets.

The purpose of coaching is to support teachers as they improve their instruction. Knight (2009) explained various coaching roles such as data coach, resource provider, mentor, and curriculum and instructional specialist. Similarly, Killion (2012) described different types of coaching. One type is cognitive coaching which develops teachers to be self-directed learners through guided reflection. This means the coach guides a teacher to come up with their own solutions instead of providing one. For example, after asking a teacher to think about how students could be more engaged during instruction, the coach supports the teacher to try out and reflect on some of her ideas. The presumption of cognitive coaching is that the teacher will begin to improve instruction without being prompted. Other coaching methods also use reflection as a way to support teacher learning. Content-focus coaching is a cycle of planning, observing, and reflecting (West & Staub, 2003). For example, a mathematics coach and teacher might co-plan a lesson to determine what questions the teacher will ask to support student understanding. Then after observing the lesson, the coach and teacher would meet again to reflect upon the enacted lesson. This coaching cycle might also be part of a peer coaching experience. This means, instead of working with a coach, teachers support each other through a similar cycle of planning, observing, and reflecting. These examples are only some of the possible coaching methods used to support teacher improvement. Although there is evidence that many US elementary teachers have access to coaching, the type of coaching they experience is unclear (NSSME; Horizon Research, 2018). For that reason, it can be assumed that coaching opportunities vary.

External PD

Many different experiences are categorized as external PD which is defined as PD that occurs outside of the regular school routine. Some examples include attending conferences and workshops, participating in a district PD, and taking part in a research partnership. In this study, external PD is further sorted into resource-focused PD and mathematics-focused PD. The purpose of resource-focused PD is to train a teacher on using or implementing a school-provided material like a textbook. Mathematics-focused PD is not focused on a resource but instead might emphasize a specific instructional or planning strategy.

Resource-focused PD. There is evidence that teachers attend PD to learn about a school-provided resource. Several articles report teachers attending PD to learn about a new textbook (Collopy, 2003; McGee, Polly, & Wang, 2013; Stickles, 2011). However, the activities that take place during the PD can be very different. For example, some PD might provide minimal opportunities to learn about mathematics. Collopy (2003) described an afternoon training provided to teachers piloting a new textbook, which only incorporated pointing out certain features of the new curriculum. On the other hand, McGee, Polly, and Wang (2013) reported on a state-funded partnership aimed to support districts with the implementation of a new curriculum. Several teachers from each school attended the sessions that started with a summer institute and continued with several meetings throughout the school year. The teachers reported the training to be beneficial and liked learning about student-centered instruction through their engagement in problem-solving tasks. In contrast, the authors found teachers skipped lessons that required a lot of preparation and activities that relinquished teacher control. Moreover, the authors discovered that teachers in testing grades went back to teacher-guided instruction to prepare students for end-of-grade assessments. In another example, researchers report on teachers' participation in PD focused on learning and implementing an assessment tool (Polly, Martin, Wang, Lambert, & Pugalee, 2015). Teachers attended face to face summer sessions and then received virtual support throughout the school year. The authors reported that many of the 138 teachers used the materials provided through the program. However, more teachers were not using the program as intended. Teachers reported common challenges such as not having enough time to prepare the materials or administer the evaluation. Teachers also expressed the difficulty in trying to connect all the school provided resources. Collectively these articles provide evidence of teachers participating in PD with an aim to learn about school provided materials. Moreover, the experiences vary.

Mathematics-focused PD. An abundance of studies can be categorized as mathematics-focused PD. In one example, Gee and Whaley (2016) describe teachers' engagement in a lesson study cycle (this type of lesson study is adapted from a teacher-led research practice in Japan). The group met during the summer to co-plan lessons and then on several occasions throughout the school year to observe, reflect, and modify the lesson. The authors hoped participants would continue in this practice after the study concluded. However, there was no follow-up information reported. In another example, Bailey (2013) partnered with a school district by providing PD aimed to help teachers recognize the coherence of the mathematics Standards. They met several times throughout three years, which included extended summer meetings. Teachers in the study reported that participation in the PD developed their ability to prepare instruction, assessments, and interactive homework.

University partnerships are not limited to face to face PD. In a final example, researchers used grant money to create and implement an online PD program aimed to improve elementary teachers' knowledge of content, pedagogy, and student learning to improve instruction for students with disabilities and students that need additional support (Griffin, Dana, Pape, Algina, Bae, Prosser, & League, 2018). Teachers liked the flexibility of the twelve-month online design. Although the authors determined an increase in teacher knowledge, student outcomes were not significantly different. This could mean that teachers need time to practice connecting new knowledge to practice or that the school culture supports traditional teaching methods, so the teacher does not feel comfortable implementing newly learned methods. In another example, an online format supported teachers in rural areas to increase their knowledge of mathematics content and practices (Luebeck, Roscoe, Cobbs, Diemert, & Scott, 2017). The project used trained facilitators to guide teachers through activities and asynchronous discussions. In addition to the positive outcomes, the authors determined that teachers assigned a highly responsive facilitator reported a more positive experience than the teachers with a facilitator that responded less often. This could mean that teachers need consistent feedback and guidance. However, it could also mean that some facilitators are more skilled than others (Borko, Koellner, & Jacobs, 2014).

As indicated by the research studies highlighted thus far in this paper and by meta-analyses (Darling-Hammond et al., 2017), most reports of research on PD are the results of university-school or university-school district partnerships. Although this pattern confirms that little is known about locally planned and implemented PD, a few examples that provide some information about these opportunities are available. In one case, Althauser (2015) provided information about the planning and implementation of a two-year district PD. The district seemed to have a deficit view of teachers' capabilities considering that participation was mandated after elementary teachers' content knowledge was blamed for the low achievement scores in the middle schools. School teams met four days per year and engaged in activities such as creating a pacing guide and formative assessments. Findings indicated positive effects on third-grade teachers' efficacy and students' test scores. Contrary to the deficit perspective, another example of district- planned PD seemed to empower teachers. Lewis, Perry, and Hurd (2009) reported on a lesson study PD that was designed by district coaches and offered during the summer. The authors said that teachers developed an understanding of mathematical concepts and student understanding. More importantly, teachers established lesson study groups in their schools during the following school year. While these are just two examples of locally planned PD that were also studied by researchers, we know that an extraordinary amount of fiscal and human resources are invested into locally planned, external PD every year.

Collectively, these aforementioned studies point to the fact that teachers participate in PD external to the school day. However, there is likely variation between opportunities (e.g., purpose, time, support), which means details of PD will help understand the opportunities teachers have.

Self-directed PD

Adult-learning theory suggests that adults will seek to learn when they need to solve problems (Merriam, 2001). Kennedy (2016) seems to agree when she states that teachers have already figured out solutions to their problems of practice. This means that regardless of what PD opportunities teachers are provided, they will find ways to improve in their role. For that reason, this study assumes teachers seek PD that is not required by the school (self-directed PD). Most likely self-directed PD will not be discussed in research studies. However, some instances found in the literature can highlight self-directed PD. For example, teachers take college courses specifically designed for teachers to learn about teaching elementary mathematics (Haver, Trinter, & Inge, 2017). In one study, Kutaka and others (2016) determined that participating in an elementary mathematics specialist (EMS) program developed teachers' knowledge and beliefs for teaching mathematics that continued to grow after the program was over. Other research shares similar results when investigating the impact courses had on teachers' knowledge and beliefs about mathematics (Campbell & Malkus, 2014). In another example, a teacher reported taking a college algebra class because understanding the concepts better mathematics improved his instruction (Battey & Franke, 2008).

There is also evidence that teachers use social media to obtain information about mathematics. Research shows teachers use Twitter to create a professional network to share resources (Forte, Humphreys & Park, 2012; Carpenter & Krutka, 2014). In one study, teachers reported that their interactions on Twitter were more valuable than locally offered PD (Carpenter & Krutka, 2014). Teachers also use sites like Pinterest to find resources and instructional ideas

(Schroeder, Curcio & Lundgren, 2019). It is also likely that teachers engage in other activities that support their mathematics instruction, such as reading books, listening to podcasts, and conducting action research.

PD Activities

The National Research Council (NRC, 2001) suggested that mathematics-focused PD should incorporate activities to develop teachers' understanding of content, pedagogy, and student learning. This recommendation is also evident in existing research. PD facilitators have focused on developing teachers' mathematical content knowledge while also focusing on instructional strategies and how students learn. For example, teachers' content knowledge increased, and their instruction included more time for student discussion after participating in PD that used video clips recorded in the participants' classrooms to facilitate discussions around student thinking (van Es & Sherin, 2010). The authors also reported that teacher talk during the sessions became more focused on student thinking and teachers began to see themselves as learners in their classrooms. In another example, positive results on teachers' perceptions about mathematics as well as content and pedagogical knowledge (Heck, Banilower, Weiss, & Rosenburg, 2008). The authors conclude that PD that address all three areas are more likely to effect practice.

This study used the NRC's recommendation along with other research studies to sort the activities teachers engage in during PD opportunities. What to Teach (W) are focused on content activities, How to Teach (H) are focused on pedagogical activities, and Why Teach This Way (Wy) are activities focused on student learning. Although this study is not attempting to evaluate teachers' PD experiences, it is assumed that participating in WHWy simultaneously increases the potential to learn about Standards-aligned instruction (NRC, 2001; van Es & Sherin, 2010; Heck et al., 2008). Examples of activities sorted by WHWy are discussed next.

What to Teach

Empirical studies show teachers engage in activities focused on planning instruction. For example, Polly (2012) collected data as he provided ongoing coaching support to four teachers. During the study, the author co-planned lessons and provided teachers with instructional resources to use during instruction. Similarly, other studies describe teachers co-planning with researchers (Chval, Pinnow, & Thomas, 2015; Geiger, Muir, & Lamb, 2016), planning with school-based coaches (Campbell & Malkus, 2011), or planning together with other teachers (Bauml, 2014; Althauser 2015). Teachers also revised or rewrote previously taught lessons (Suh & Seshaiyer, 2015; Murata, Bofferding, Pothen, Taylor & Wischnia, 2012). In one example, teachers worked together to create a student task from a textbook problem (Oslund, 2016). Other teachers unpacked lessons from a newly adapted textbook (McGee, Polly, & Wang, 2013). For example, Collopy (2006) described how one teacher read the teacher notes in the textbook to determine how she should implement the lesson. Teachers also planned how resources would be used. For example, teachers discussed which manipulatives and games would best fit into a lesson (Bauml, 2014) while others teachers selected activities or materials to use in with students (Borko, Mayfield, Marion, Flexer, & Cumbo, 1997; Hunter & Hall, 2008; Forte, Humphreys & Park, 2012; Stein & Coburn, 2008; Stein, Smith & Hughs, 2008; Baxter, Ruzicka, Beghetto & Livelybrooks, 2014).

How to Teach

Empirical studies show two ways in which teachers engage in activities focused on how to teach. The first is by taking a student perspective. This happens when a facilitator models an instructional strategy by assuming the role of a teacher, and the teacher engages in the lesson as a student. In one example, teachers participating in a yearlong PD focused on cognitively demanding tasks had the opportunity to engage in lessons at the start of each session. This provided the facilitator to model how to implement this type of lesson. The finding show that the PD had significant impact on knowledge and beliefs. On the other hand, observations showed that teachers were just beginning to use the demonstrated practices during their own instruction. This suggests that knowledge and beliefs change before instruction changes. Perhaps teachers are reluctant in trying new methods because these experiences bring awareness to a lack of conceptual understanding. For example, teachers' confidence in their ability to solve mathematics problems decreased after participating in PD that included experiencing a lesson from a student perspective (Zwiep & Benken, 2013). For example, in one session, teachers worked together on a student task that examined the slope of a ramp while the facilitators modeled a collaborative learning environment that valued the process of problem solving. According to the authors, the experiences confronted teachers' understanding of mathematics which resulted in decreased confidence. On the other hand, it is possible participating in activities as a student might not have any effect. For example, researchers concluded that teachers' beliefs about mathematics influence their engagement during PD after facilitating 4th and 5th grade teachers in a student task (Battey & Frank, 2008). For instance, the teacher that believed mathematics is a collection of steps and formulas, solve the task by copying the method of another teacher. She could not explain or generalize but she was very proud at how quickly she finished. In comparison, a teacher that lacked confidence solved the problem without engaging with others in the group. Later he admitted that he did not want his co-workers to know that he did have a good understanding of mathematics. This provides evidence that a safe supportive environment promotes learning. Although these articles report different outcomes, they provide evidence that engaging in a lesson as a student provides teachers with opportunities to learn about content and pedagogy.

The second way in which teachers engage in activities focused on teaching is by observing and practicing instructional strategies. PD focused on lesson study provided teachers multiple opportunities to watch instruction as well as time to practice new teaching methods (Fernandez, 2005; Suh Seshaiyer, 2014). In one example, observations led teachers to pay more attention to student learning when it was their turn to teach (Murata, Bofferding, Pothen, Taylor, & Wischnia, 2012). Manipulatives were the focus of a different lesson study, which allowed teachers to practice explaining fractional models (Lewis & Perry, 2017). Other PD used videos to highlight a specific instructional strategy. For example, teachers watched a video about how questioning can be used to engage students in a lesson (Santagata, Kersting, Givvin & Stigler, 2011). Teachers were also provided time to practice when they implemented a new teaching strategy between PD sessions (Clark et al., 2013). These experiences are important because teachers may have uncertainties about what instruction should look like and question if they are doing it correctly (Stickles, 2011). Moreover, there is confusion of how student-centered lessons prepare students for end-of-grade assessments (McGee, Wang, Polly, 2013).

Why Teach this Way

To understand the why of teaching, teachers engaged in activities focused on how students learn and understand mathematics. The literature showed that some teachers spend time analyzing student work (Garet et al., 2016; Kazemi & Franke, 2004). In one example, the facilitator asked teachers to think about and explain incorrect responses (Santagata, Kersting, Givvin, & Stigler, 2011). Other teachers discussed student thinking after watching videos of classroom instruction (van Es & Sherin, 2010; van Es, 2012). Other activities provided teachers time to make sense of the Standards. In one example, teachers participating in a district-led PD developed a curriculum by first examining Standards and then compiling resources that were aligned (Althauser, 2015). In another example, teachers practiced using Standards-aligned formative assessments to plan further instruction (Polly, Martin, Wang, Lambert & Pugalee, 2016). Why activities also included prompted reflections where the facilitators asked the teacher to reflect on a particular topic. For example, while watching a video of her instruction, a teacher was asked to reflect on the lack of opportunities a specific group of students had to participate in the lesson (Chval, Pinnow, & Thomas, 2013).

School Context

School context is circumstances specific to a school. This can be thought about as anything that makes the school unique like the location and characteristics of the people in the school community (e.g., teachers, students). Additionally, school context can be described by the expectation and decisions set by the school principal. For example, how much time is spent on mathematics instruction and which teachers attend external PD. This means school principals impact what happens at the school. In fact, the way in which a school is led can positively impact instruction and student learning (Hitt & Tucker, 2016; Patton, Parker, & Tannehill, 2015; Robinson, Lloyd, & Rowe, 2008). Therefore, it is reasonable to think that principals' decisions around the daily schedule, provided resources, and school-based coaching could potentially influence mathematics teaching and learning.

Schedule

It can be assumed that many factors (e.g., student needs, available staff) influence the school schedule, which can explain some of the variations in opportunities to engage in embedded learning opportunities. For example, Stein and Coburn (2008) reported different ways in which school schedules allowed time for teachers to collaborate. Some schools had designated times for PLCs to meet to discuss mathematics while others did not. One school combined the student lunchtime with teacher planning time, which made attendance to PLC meetings inconsistent. Teachers might also have opportunities to collaborate if they are provided planning periods during which they are not responsible for students. Bauml (2014) described how a new teacher used daily planning to work with other teachers about mathematics. Together these articles show decisions about the school's schedule can encourage or hinder learning opportunities.

Resources

Teachers have access to different resources that may influence their mathematics instruction. For example, some teachers might be provided with a Standards-aligned curriculum (Harmon, Gordanier, Henry & George, 2007; Stein & Coburn, 2008; Stickles, 2011). Often, curriculum materials include teacher PD components like assessment guides, student samples, and suggestions on facilitating a student-centered lesson (Superfine, Kelso, & Beal, 2010). For this reason, the instruction may shift, which is why NCTM (2014) recommends providing such resources. However, providing a textbook does not necessarily change teaching because teachers perceive and use the provided resources differently. For example, Brown (2009) found that teachers enacted lessons differently than the Standards-aligned textbook suggested. Other research had similar findings (Sherin & Drake, 2009). Therefore, it could be assumed that providing a resource should be accompanied by opportunities to discuss and understand how the resource can support a shift away from traditional instruction. Although these examples focus on textbooks, it can be assumed that other resources such as manipulatives and games would also require PD. It can also be assumed that school principals make decision around which resources are provided, how much time will be allotted to discuss resources, and the expectation of use.

School-based Coaching

In order for coaching to be effective, coaches need to spend time with teachers. However, the coaching role might include non-instructional duties. Neufeld and Roper (2003) found that the principal's beliefs influenced how the coach was utilized. This means some coaches carry out non-instructional duties like organizing material. Other studies report similar findings (Salkind, 2010; Stein & Kaufmann, 2010). On the other hand, principals that are involved in teacher PD tend to delegate responsibilities to coaches that focus on the development of teachers. Consequently, the school schedule includes time for the coach and teacher to meet. However, working with a teacher during scheduled times will only be effective if the coach has specialized skills (Gibbons & Cobb, 2016) that include expert content knowledge as well as experience working with adult learners. Principals need to be aware that some new coaches might be uncomfortable providing staff PD or unsure of how to handle teachers that are resistant to coaching (Chval, 2010). Ellington and Havar (2013) suggested that new coaches can practice by coaching teachers that want to be coached. Collectively, these articles suggest that school decisions can impact the role coaches have on teacher learning.

In conclusion, the literature reviewed provided evidence that PD is likely to vary by type, activities, and school context. It could be assumed that teachers' experiences can be sorted in a similar fashion. For that reason, the components of the TLO-M directly connect to the literature (See Table 2.1). The remainder of this chapter will discuss the creation of the TLO-M.

Table 2.1
Connections Between Theoretical and Empirical Research

TLO-M Components	Theoretical Research: Ideas from Features of Effective PD (Darling-Hammond et al., 2017)	Theoretical Research: Ideas from Mathematics Teaching Practices (NCTM, 2014)	Theoretical Research: Ideas from Mathematical Knowledge for Teaching (Ball et al., 2008)	Empirical Research
Type	PD should be collaborative, span over time, and include coaching/expert guidance.	Shifting instruction will require training.	Specialized knowledge and skills are needed to teach mathematics. Therefore, PD is necessary.	There are different types of PD.
Activities	Activities should be content focused and engage teachers in inquiry around practice.	Activities should develop mathematics teaching practices.	Activities should develop specialized content and pedagogical knowledge.	PD activities focus on different aspects of teaching.
School Context	Schools can provide time, training, and resources to support PD.	School leaders need to be aware shifting instruction takes time.	School leaders need to be aware that developing this knowledge takes time.	School context can influence PD opportunities.

The Creation of the TLO-M

The literature reviewed provided evidence that PD varies by type and activities. There was also evidence that school context influences PD opportunities. This means that information about type, activities, and school context can be used to understand teachers' PD experiences. For that reason, type, activity, and school context are the three components of the TLO-M.

There are three kinds of TLO-M items; one for each of the three components. Table 2.2 shows an example of the items used to inquire about type, activity, and school context. Notice the response choices for each is different. This will be discussed more in about scoring in Chapter 3.

Table 2.2
TLO-M Example Items

Component	Purpose of Items	Example	Example Response
Type	Determine type of PD	How often did you participate in grade-level PLC meetings during the 2018/19 school year?	a. 0= never b. 1= a few times per year c. 2= about quarterly d. 3= about monthly e. 4= about weekly f. 5= about daily
Activity	Determine WHWy activities included in PD	Did modify pre-written lesson plans to meet the needs of your students?	a. Yes b. No
School Context	Determine information about the school context	Which best describes how you accessed the mathematics Standards?	a. My school provided me with this resource. b. My school provided me time to find or create this resource. c. I was not provided this resource or time to find or create this resource.

Items were created from the information found in the literature. For example, items ask about how often teachers participate in PLC meetings and coaching because there was evidence PLC and coaching are ways in which teachers learning about Standards-based mathematics instruction. The creation of the activity items required an additional step. This was so the items connected to both theoretical and empirical research. First, a list of activities was generated using what was found in the empirical studies and from my own experiences as a teacher and curriculum coach. Then I sorted each into a WHWy category and sorted again by MKT domain (Ball, Thames, & Phelps, 2008) (See Appendix M). This means each activity was double sorted. Table 2.3 provides an example of how one item was sorted using this method. In this case, "observing a coach teach a mathematics lesson" is classified as a How to Teach (observation and practice) because it provides a potential opportunity to see Standards-aligned instruction. The activity is also sorted into the Knowledge of Content and Teaching domain because it potentially provides information on the best way a lesson might be taught.

Table 2.3
Sort Used to Create TLO-M Activity Items

	Mathematical Knowledge for Teaching (MKT) Ball, Thames & Phelps, 2008			
	Common Content Knowledge	Specialized Content Knowledge	Knowledge of Content and Students	Knowledge of Content and Teaching
Content What to Teach				
Pedagogy How to Teach				Observing a coach teach a mathematics lesson
Student Learning Why Teach This Way				

After creating the TLO-M items, Qualtrics software was used to create a web-based survey. The next step was to determine if the TLO-M could be used to explain teachers' PD experiences. Information about the validation process and scoring guide will be discussed in Chapter 3.

Chapter Summary

In the first part of this chapter, research was used to show that implementation of the CCSS-M requires PD. This is because the implementation of instruction is different and providing such instruction requires specialized knowledge. Although little information is known about the majority of teachers' experiences, there is evidence of three distinct types of PD and how activities teachers engage in during PD can be sorted by the focus. Other research was used show school context can influence the teachers' PD opportunities. The second part of this chapter introduced the TLO-M as a way to measure teachers' PD experiences. Table 2.4 shows how theoretical and empirical research influenced the creation of the TLO-M. The next chapter discusses the validation of the TLO-M and the methods of this study.

Table 2.4
Connections Between TLO-M and Previous Research

	TLO-M Components	**Effective Feature of PD** (Darling-Hammond, Hyler, & Gardner, (2017)
Empirical Studies Used to Define TLO-M Components	Type	• Collaboration • Duration • Coaching and Expert Support **MKT** (Ball et al., 2008) **MTP** (NCTM, 2014)
	Activities	• Content focused **MKT** (Ball et al., 2008) **MTP** (NCTM, 2014) • Active Learning **MKT** (Ball et al., 2008) **MTP** (NCTM, 2014)
	School Context	• Models of Effective Practice **MKT** (Ball et al., 2008) **MTP** (NCTM, 2014) • Coaching and Expert Support

CHAPTER 3: METHODOLOGY

As seen in the literature review, teachers participate in different types of PD and activities that could potentially develop the skills and knowledge needed to teach student-centered mathematics. National surveys provide some information about teachers' PD opportunities. However, because the majority of PD is locally implemented and go unreported, much is still unknown. Using a two-phase, explanatory, sequential mixed-methods design, this study attempts to contribute to the field by adding to what is known about teacher PD. The following research questions guided this study:

1) From the perspective of elementary school teachers working in the same district, in which mathematics-focused learning opportunities do teachers engage?
2) What is the relationship between mathematics-focused learning opportunities and other factors (e.g., grade level, years of experience, school contextual factors)?
3) What additional information can school documents and interviews with school leaders provide when trying to understand the relationship between school context and teachers' embedded learning opportunities?

In order to address the research questions, the TLO-M needed to be validated as a measure. Therefore, this chapter is divided into two parts. The first part presents the pre-study validation and TLO-M scoring guide. Then the second part of the chapter will introduce the mixed-methods study, the participants, data collection, and data analysis.

Part One

Pre-Study: Validation of the Instrument

The TLO-M was created as a tool to quantify opportunities elementary teachers have to participate in mathematics-focused PD. The development process included validation. This section will describe the validation plan, data sources, results and modification, and a rationale of its validity.

Validation Plan

According to the *Standards for Educational and Psychological Testing* (SEPT; AERA et al., 2014), "A sound validity argument integrates various strands of evidence into a coherent account of the degree to which existing evidence and theory support the intended interpretation of test scores for specific uses" (p.17). Therefore, to establish validity I defined the measure and its use and provide multiple forms of evidence of support. Three sources of data were used to justify the use and purpose of the TLO-M. First, an expert review panel was used to establish content validity (test content evidence). Content validity is defined as the “the degree to which items in an instrument reflect the content universe to which the instrument will be generalized” (Straub, Boudreau et al. 2004) and is recommended during the development stage of a survey (Groves, Fowler, Couper, Lepkowski, Singer, & Tourangeau, 2011). Second, several rounds of cognitive interviews were used to establish face validity (response processes evidence). Face validity can help determine if the instrument measures what it is intended to measure (Taherdoost, 2016). Cognitive interviews with teachers allowed me to understand how the instrument was understood by the population for which the TLO-M was developed (Tourangeau et al., 2000) and are used to support survey validity in educational research (Desimone & Le Floch, 2004). Finally, data collected through a pilot test provided data to confirm the events and activities found in the literature review match teachers’ experiences.

Sources of Validity Evidence

This section is divided into three subsections that describe the sequential way in which the TLO-M was refined. The first two, expert review and cognitive interviews, contributed significantly to the modifications made to the TLO-M. The third, pilot study, confirmed the TLO-M is a valid measure of teachers' learning opportunities in mathematics.

Expert review. The four experts all serve as members of the researcher's dissertation committee. However, the individuals were not chosen because of convenience. Collectively, they bring expertise in teacher learning, mathematics education in the elementary grades, survey development, and measurement validity. In June 2019, each expert received a paper and a digital copy of the TLO-M and was asked to provide content feedback for items and answer choices. Written and oral feedback was collected.

Cognitive interview. The participants for the cognitive interviews were recruited through convenience, yet purposefully selected. A list of possible participants was created by asking colleagues for names and email addresses of teachers that fit the criteria of (1) being a classroom teacher in a school located in the United States, (2) not being a special education teacher, and (3) teaching mathematics to students in K-5 during the 2018/19 school year. An email was sent to invite teachers from different grade-levels and with various years of experience. Five teachers participated in cognitive interviews by meeting face to face or virtually via Zoom. See Table 3.1 for characteristics of cognitive interview participants.

Three rounds of cognitive interviews occurred between June and September 2019. Two teachers were interviewed during round one using the first version of the TLO-M. During round two, the third participant was interviewed using the second version of the TLO-M. Round two also included written feedback from the teachers interviewed in round one after they took the newer version on their own. For round three, two additional teachers were interviewed using the third version of the TLO-M. The same format was used to conduct interviews during the three rounds. First, each participant received a digital copy of the consent form. A link to access the

TLO-M was emailed to each participant five minutes before the scheduled interview. Each participant verbally agreed to participate and have the interview recorded. During the interview, participants were asked to "think aloud" as they read and answered TLO-M items. After completing the survey, the researcher asked participants about specific wording of items and answer choices.

Table 3.1
Characteristics of Cognitive Interview Participants

Characteristics of Pilot Study Participants		***N***
Age (years)	29 or less	2
	30-49	2
	50 or more	1
Gender	female	4
	male	1
Teaching Experience (years)	5 or less	3
	6-14	1
	15 or more	1
Years Teaching at School	5 or less	3
	6-14	2
Grade Taught During the 2018/19 School Year	Second	2
	Third	1
	Fourth	1
	Fifth	1
Degree	Bachelor's	1
	Master's	4
State	North Carolina	3
	Virginia	1
	Illinois	1

Pilot Test

For about four weeks between July and August 2019, teachers were invited to participate in the pilot test through anonymous links shared on Facebook and Twitter. The researcher and the committee chair posted links to the digital survey on their personal Facebook pages as well as in one public group and five closed groups. The groups were targeted toward elementary teachers. Requests sent to the administrators of closed groups obtained permission to post the link on the group page. The survey was also shared multiple times by other Facebook users. The survey was tweeted three times and retweeted one time. All participants consented to participate in the study before starting the survey.

A total of 179 teachers agreed to participate in the pilot test. However, the sample was narrowed to 101 after omitting incomplete surveys and surveys completed in under five minutes. The participants were mostly female (95%) teachers that taught mathematics to elementary students in public (97%) schools during the 2018/19 school year. Table 3.2 lists additional characteristics of the pilot study participants about their age, years of teaching experience, years at current school, and highest degree earned.

Table 3.2
Characteristics of Pilot Study Participants

Characteristics of Pilot Study Participants		***n***	**%**
Age (years)	29 or less	18	18%
	30-49	59	58%
	50 or more	24	24%
Teaching Experience (years)	5 or less	17	17%
	6-14	39	39%
	15 or more	45	44%
Years at Current School	5 or less	46	45%
	6-14	34	34%
	15 or more	21	21%
Degree	Bachelor’s	31	31%
	Master’s	70	69%

Results: Validity Evidence

Expert reviews. The purpose of the expert review was to establish content validity. The verbal and written feedback collected was used to make minor changes to the TLO-M. For instance, the definitions for PLC and coaching were tweaked and some answer choices were modified for clarity.

Feedback was also provided during the creation of the scoring guide which was being developed throughout the validation study. For example, it was decided that not all scores would be created for each teacher. This means if a teacher did not have an opportunity, there was no score instead of a zero. Therefore, scores represent experiences. The scoring is discussed later in this chapter.

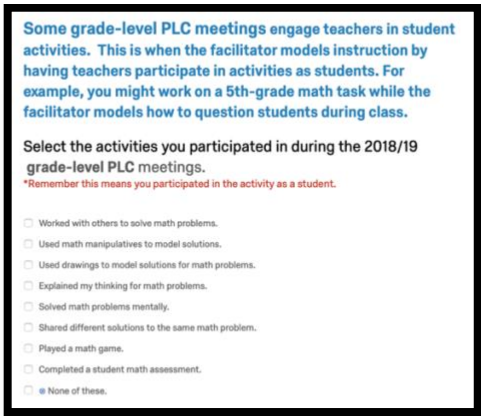
Cognitive interviews. Table 3.3 includes a complete log of all changes that were made to the survey over the course of the cognitive interviews. In this section, I highlight the most significant changes and demonstrate how the cognitive interview data directly informed the changes.

Round one. The round one interviews revealed three major problems with the survey: the response options for access items, clarity of the activity items, and the need for formatting changes.

Access items use a multiple-choice question to inquire about school provided resources (Standards, pacing guide, lesson plans, manipulatives). Teachers were asked to choose one response from the following choices (1) My school provided me with this resource; (2) My school provided me time to find or create this resource; or (3) My school did not provide me the resource or time to find or create the resource. The two teachers that were interviewed during round one both indicated choosing two items better represented their experience. For this reason, the access items were changed to allow for multiple responses.

Second, there were some clarity issues with the activity items. One problem was the teachers did not understand the difference between the How (student perspective) item and the Why (student learning) item. After providing an explanation of the items, there was still confusion which seemed to be around the How (student perspective) item. For that reason, the item was replaced with a multiple-choice question. Figure 3.1 shows the original item (left) and the replacement item (right).

Original Item



Replaced Item

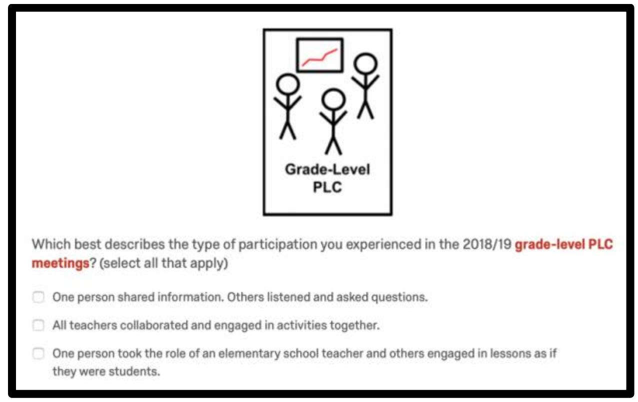


Figure 3.1. TLO-M original and replacement item.

A second issue with the activity items was presented when one teacher said she met with a coach but only to ask a quick question. This meant she did not engage in any of the WHWy activities. However, because she answered yes to coaching frequency, the activity items followed. This seemed like a waste of time. Therefore, a filter item was added to the coaching items (See Figure 3.2). This means the activity items would only be asked if the participant chose the response “We collaborated and engaged in activities together.”

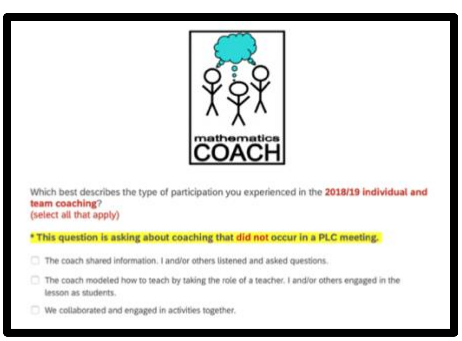


Figure 3.2. Coaching item used to filter activity items.

Third, the overall formatting of the survey needed to change. This was decided because of the difficulty teachers had keeping up with where they were on the survey. For instance, the teachers forgot what event activity items were asking about. One teacher said, “I forgot what I am answering about.” To address this design issue, a description of each section was added along with icons to represent different events (See Figure 3.3). Now an icon reminds the teacher the topic of each item.

Figure 3.3. *Examples of TLO-M icons.*

Round two. The changes made after round one interviews were determined to be successful during the round two because the response options matched teachers’ experiences, the items were understood as intended, and there was no confusion on the topic of each item. However, round two revealed the survey was too long and some of the choices in the activity items were repetitive. For example, one teacher said the survey took a long time to complete. Another teacher said list of activity items seemed "redundant," specifying that she did not see a difference between "analyzed student work samples" and "analyzed mathematics work completed by students in my class." To address the issue of length, several items were deleted. The deleted items were questions that were considered extra. For example, one deleted item asked about the location of the external PD and another asked about the PD facilitator. Although the items would provide information about the PD experience, they were determined to be non-essential due to not being attached to a TLO-M component (type, activity, school context). Some other activity items were shortened. Figure 3.4 shows an example of how the activity items were modified. The new item shown on the right has half the choices of the original item shown on the left.

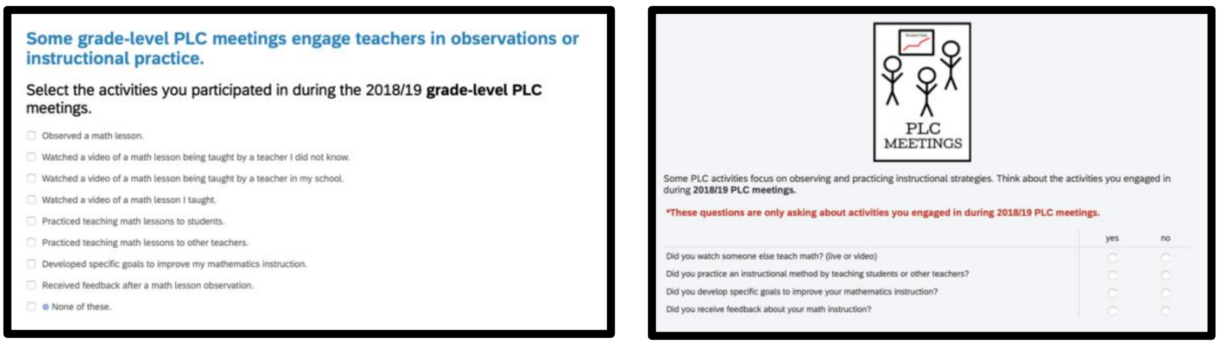


Figure 3.4. Modification made to address redundancy (original item is shown on the left and the modified item on the right).

Round three. It was difficult for participants to separate grade-level and vertical PLC activities as well as individual and team coaching activities. This was due to each being considered as an independent event. For instance, a frequency item would inquire about individual coaching opportunities and if applicable, individual coaching activities. Later in the survey, a frequency item inquired about team coaching opportunities and if applicable, team coaching activities. This was determined to be a problem after one teacher asked if she could change her answers. The request prompted a conversation around the four items. The teacher explained that segregating the related events was difficult. For that reason, the items were reorganized and combined. Now, one item asks about the frequency of grade-level and vertical PLC opportunities and is followed by activity items if applicable. Likewise, one item asks about the frequency of individual and team coaching opportunities and is followed by activity items if applicable. Figure 3.5 shows the modified coaching item.

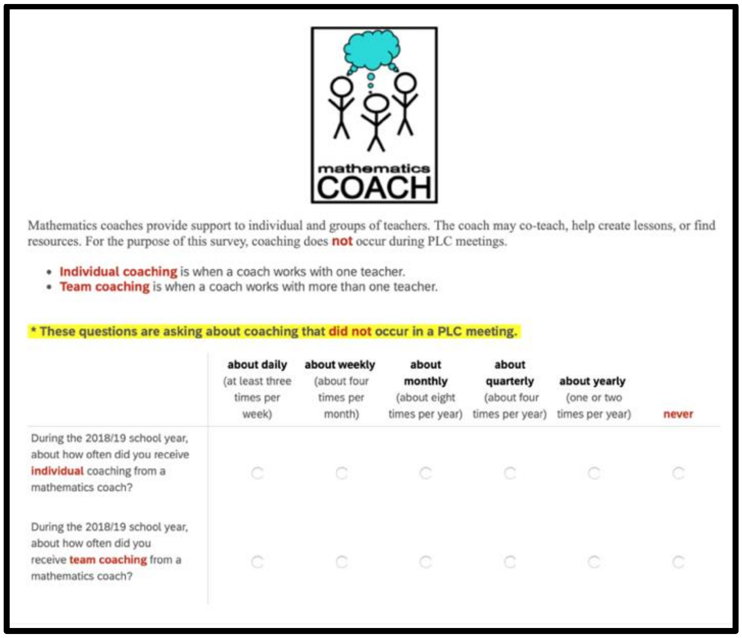


Figure 3.5. Modified coaching item.

As noted earlier, Table 3.3 indicates the changes discussed above as well as other minor changes made to the TLO-M before the survey was used in the main study. Next the pilot test results are discussed.

Table 3.3
TLO-M Modifications Prompted by Validation Process

	TLO-M Versions			
Items	TLO-M Version 1	TLO-M Version 2	TLO-M Version 3	TLO-M Main Study
Access to Resource Items	• Participants wanted to click on more than one choice for lesson plan access. Specifically, they wanted to choose “school provided lesson plan resource” and “school provided time to create lesson plans with other teachers”.	The change was made to allow participants to choose multiple responses for lesson plan resource items. The modification was determined to be successful because it was not an issue for participants in round two and three of cognitive interviews.		

Table 3.3 (continued).

Frequency Items	• Round one interview participants understood the scale and the options fit their experiences.	• An item inquiring about *Individual Planning* was inserted to understand embedded opportunities that were teacher chosen. • Response choices for external PD changed from the number of sessions and hours to the same frequency scale as embedded PD.	• To clarify the definition, *Individual Planning* was changed to *Planning Period.*	• External PD response choices were changed from being the same as embedded PD to inquiring about hours. However, a 0-5 scale as still used (0= less than one hour, 1=between one and two hours, 2= between three and eight hours, 4=thirteen and nineteen hours, 5=twenty or more hours).
WHWy Activity Items	• Round one interviews suggested that coaching activities occurred as needed. For example, the teacher would find the coach when she had a question. This made the coaching activity items seem unnecessary. • Participants clicked on one or more activities for each item. When asked clarifying questions, it was unclear if the activity occurred or the participant wanted to click on something in each section.	• A filter question was added before coaching activitity items. If coaching included collaborative work, the activity questions followed; If not, activity questions were skipped. • Filter questions were added before each activity item. For instance, before getting to the item that listed What to Teach activities, a filter item defined What to Teach and asked if the PD incorporated these types of activities. The participants that indicated yes, would be asked		• Filter questions removed. Yes/no sub-items included within the activity items as a way to specify the exact activities teachers engage in. • Wording and definitions were edited as needed.

Table 3.3 (continued).

	• How Items (student perspective) were not understood as intended. After defining the question, both participants considered the How Items (student perspective) and the Why Items (student learning) as the same activities. • Why Items (reflection) were not understood as intended. Participants answered the question by thinking about how they reflected on the PD, instead of thinking about how reflections were used in the PD as a prompt by the facilitator.	the What to Teach items. This changed the number of activities clicked in round two of the interviews. Specifically, less activities were incorporated into the PD opportunity. • The original How Items (student perspective) were removed and replaced with a multiple-choice item that asked teachers how they participated in the PD. How (student perspective) was determined if a teacher indicated they engaged in the PD as a student as someone else (coach, facilitator) took the role of the teacher. • Reflection items included bold print and a reminder that the item is only asking about prompted reflections.		
School Context Items	• Two items that asked about time of day and time of year seemed redundant to the participants.	• Location and facilitator questions were deleted. Time of day and time of year items were combined.	• Modifications to self-directed learning items were made to only inquire about frequency.	• Items added to inquire about characteristics needed for the main study (e.g., grade level, school name).

Table 3.3 (continued).

	• Presenting and attending a conference needs to be added to SDL.			• Items that asked what state the teacher worked in was deleted. • Response items were combined for some demographic items (e.g., age, years teaching).
TLO-M Format	• Participants were confused with items that repeated and verbally reminded themselves which section they were in as they thought about their experience.	• Section descriptions were added to let participants know what to expect next. Icons and colored and bold text were included to remind participants of section and definitions.	• Sections were reorganized. **Previous Order** 1. Resources (access, use, and external PD) 2. Individual coaching 3. Grade-level PLC 4. Team PLC 5. Planning period 6. Team coaching 7. Self-directed PD 8. Other external PD 9. Demographics **New Order** 1. Resources (access and use) 2. Daily Schedule (individual coaching, grade-level PLC, vertical PLC, planning period, team coaching) 3. External PD 4. Self-Directed PD 5. Demographics	• Items were combined so one item asked about individual and team coaching. • Items were combined so one item asked about team and vertical PLC. • Font and color scheme were altered to be consistent throughout.

Pilot Test

The TLO-M items are based on PD literature, so the purpose of the pilot test was to confirm the items represented teachers' actual experiences. The results show teachers participate in embedded, external, and self-directed PD, and engage in activities focused on WHWy during those opportunities. Moreover, school context varies. Findings are discussed next. However, it is important to note that the same data was not collected from each participant. This is because the TLO-M utilized skip logic. Skip logic creates custom paths for each participant based on their responses. For instance, if a teacher indicated she had access to a lesson plan resource, the next item would ask about how often she used the resource to plan and teach mathematics. On the other hand, that item would be skipped for a teacher that indicated no access to a lesson plan resource. For this reason, the number of responses is noted in each area.

Embedded PD. Data collected during the pilot study indicate potential learning opportunities occurred during planning periods, PLC meetings, and coaching opportunities (See Table 3.4). Each is discussed next.

Planning period. Planning periods provide teachers time to plan lessons, prepare materials, and collaborate with other teachers. For that reason, planning periods create potential learning opportunities. Data from 65 teachers determined that most of the sample (n=54) were provided with this opportunity. The frequency of planning periods varied, with many teachers (n=38) having planning periods at least weekly, other teachers (n=10) about monthly, and some teachers (n=6) four times or less per year. Additionally, 11 teachers said they never had a planning period. This provided evidence that time provided for planning is different between teachers which could mean some teachers have more opportunities to learn about mathematics.

PLC meetings**.** PLCs meetings provide teachers time to discuss mathematics. For this reason, PLC meetings provide potential learning opportunities. Data collected from 67 teachers determined the majority of teachers (n=54) participated in grade-level PLC meetings. More than half of the teachers (n=34) indicated that PLCs met at least weekly, other PLCs (n=14) met about monthly, and some PLCs (n=9) met four times or less per year. Additionally, 13 teachers said they never met with a grade-level PLC to discuss mathematics. This provided evidence that teachers participate in PLCs focused on mathematics and that their experiences vary.

Data collected from 66 teachers determined fewer opportunities to participate in vertical PLC meetings with the majority of teachers (n=50) reporting that they never participate in vertical PLC meetings. This provided evidence that only some teachers meet with vertical PLCs to discuss mathematics. This finding also justified the decision made after cognitive interviews to modify the TLO-M so that participants answered only one set of PLC activity items.

Coaching. Coaches can provide teachers with potential learning opportunities. Data collected from 66 teachers was used to determine that some teachers (n=27) have individual coaching opportunities. The frequency of individual coaching varied with some teachers (n=10) being coached at least weekly. The data collected from 63 teachers showed similar opportunities for team coaching. Twenty-seven teachers indicated participation in team coaching with some teachers (n=10) having opportunities at least weekly. The findings also show that most of the teachers that receive coaching (n=21) participated in both team and individual coaching (See Table 3.5). These findings provided evidence that some teachers have coaching opportunities. This finding also justified the decision made after cognitive interviews to modify the TLO-M so that participants answered only one set of coaching activity items.

Table 3.4
Frequency of Embedded PD (Pilot Study)

	About Daily	**About Weekly**	**About Monthly**	**About Quarterly**	**About Yearly**	**Never**
Planning Period	10	28	10	2	4	11
Grade-level PLC	6	25	14	6	3	13
Vertical PLC	1	1	1	4	8	50
Team Coaching	2	8	5	6	6	36
Individual Coaching	1	9	5	7	5	39

Table 3.5
Frequency Coaching Opportunities (Pilot Study)

	number of teachers
Coaching Experiences	
Individual Coaching Only	6
Team Coaching Only	6
Both Individual and Team Coaching	21

External PD. Data collected during the pilot study indicated teachers participate in external PD. Additionally it was confirmed that some PD focused on provided resources and some PD did not (See Table 3.6). Each is discussed next.

Resource focused PD. Although 75 teachers in the sample indicated that the school provided a lesson plan resource, few teachers (n=16) attended PD focused on the provided lesson plan resource. The results show variation in PD contact hours with some teachers (n=12) attending between 1-19 hours and other teachers (n=4) attending twenty or more hours. Forty-four teachers in the sample indicated that they were provided with a digital resource. Ten of these teachers participated in PD focused on the provided digital resource. Although the contact hours varied, no teacher participated for twenty or more hours. These findings provided evidence that some teachers attend PD to learn about provided resources. In the same way, there is also evidence that some teachers do not attend PD to learn about the provided resources. This could mean that teachers are not given adequate training on the resources they are provided. However, the TLO-M only inquired about PD that occurred during the 2018/19 school year, so it is possible teachers previously participated in resource PD.

Mathematics-focused PD. Data collected from 62 respondents were used to determine that some teachers (n=23) participate in mathematics-focused PD that is not specific to a provided resource. Results show contact hours varied with some teachers (n=5) attending for twenty or more hours and other teachers attending less than twenty hours (n=18). This provided evidence that teachers have different opportunities to attend mathematics-focused PD.

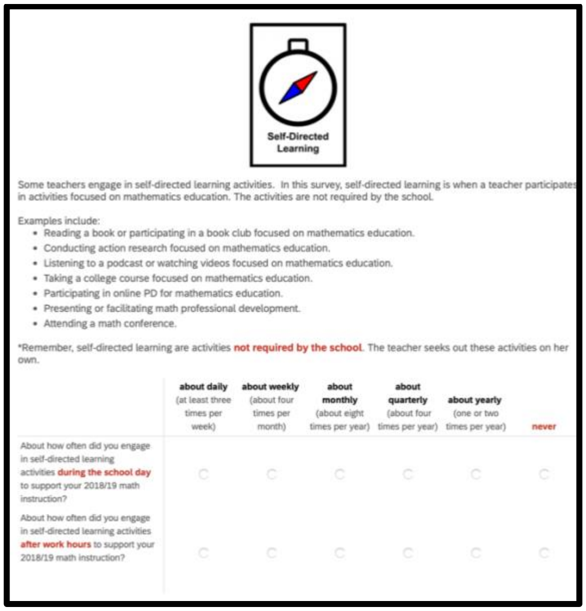
Table 3.6
Frequency of External PD Contact Hours (Pilot Study)

	20 or more hours	Between 10-19 hours	Between 1 and 9 hours	Less than 1 hour
Lesson Resource PD (n=16)	4	4	8	0
Digital Resource PD (n=10)	0	2	7	1
Mathematics-focused PD (n=23)	5	8	9	1

Self-Directed PD. Data collected from 62 teachers provided evidence that teachers engage in self-directed PD. Table 3.7 shows the frequency of activities reported during and after work hours. It was common for participants to read a book (n=59) and watch videos focused on mathematics education (n=61). It was less common for participants to meet with a book club (n=3). It is important to note that self-directed items were modified before the main study so that the responses aligned with other frequency items. Figure 3.6 shows the modified items.

Table 3.7
Frequency of Self-Directed PD (Pilot Study)

Self-Directed Activities	During Work Hours	After Work Hours
Read a book focused on mathematics education.	24	35
Met with a book club to discuss a mathematics education book.	3	0
Conducted action research focused on mathematics education.	3	8
Listened to a podcast focused on mathematics education.	6	13
Took a college course focused on mathematics education.	2	5
Participated in an online PD for mathematics education.	15	24
Watched videos focused on mathematics education.	24	41
Presented or facilitated a mathematics training for my school.	12	6
Presented or facilitated mathematics training for my district.	5	2
Presented or facilitated a mathematics training outside my district.	2	2



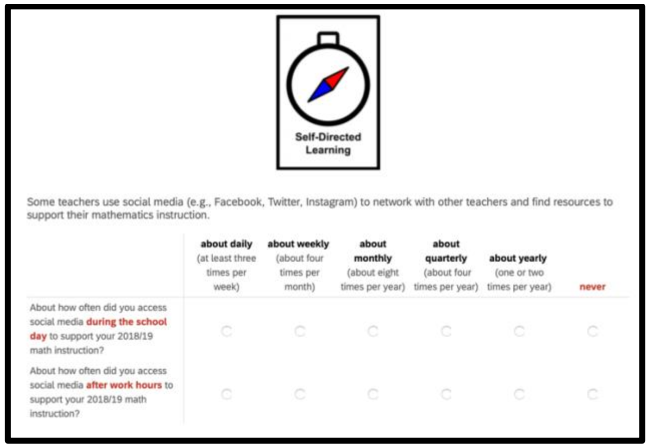
Self-Directed Learning

Some teachers engage in self-directed learning activities. In this survey, self-directed learning is when a teacher participates in activities focused on mathematics education. The activities are not required by the school.

Examples include:
- Reading a book or participating in a book club focused on mathematics education.
- Conducting action research focused on mathematics education.
- Listening to a podcast or watching videos focused on mathematics education.
- Taking a college course focused on mathematics education.
- Participating in online PD for mathematics education.
- Presenting or facilitating math professional development.
- Attending a math conference.

*Remember, self-directed learning are activities **not required by the school**. The teacher seeks out these activities on her own.

	about daily (at least three times per week)	**about weekly** (about four times per month)	**about monthly** (about eight times per year)	**about quarterly** (about four times per year)	**about yearly** (one or two times per year)	**never**
About how often did you engage in self-directed learning activities **during the school day** to support your 2018/19 math instruction?						
About how often did you engage in self-directed learning activities **after work hours** to support your 2018/19 math instruction?						



Self-Directed Learning

Some teachers use social media (e.g., Facebook, Twitter, Instagram) to network with other teachers and find resources to support their mathematics instruction.

	about daily (at least three times per week)	**about weekly** (about four times per month)	**about monthly** (about eight times per year)	**about quarterly** (about four times per year)	**about yearly** (one or two times per year)	**never**
About how often did you access social media **during the school day** to support your 2018/19 math instruction?						
About how often did you access social media **after work hours** to support your 2018/19 math instruction?						

Figure 3.6. *Modified self-directed learning items.*

WHWy activities. Data collected during the pilot study provided evidence that teachers engage in a variety of WHWy activities. Table 3.8 shows how teachers responded to the activity items throughout the survey. The specific number of participants that engaged in each activity provides information like it was more common for teachers to find and share resources than observe instruction. However, the data were looked at more generally to determine that WHWy occur in each type of PD. Therefore, there is evidence that WHWy items can be used to describe teachers' experiences. Note, as discussed earlier, modifications were made to make the activity items less wordy, so although similar, the items shown in this section are not the exact WHWy items used in the main study.

Table 3.8
Frequency of Activities Items (Pilot Study)

What to Teach Activities	IC	PLC	V PLC	Plan	TC	LPR PD	DR PD	M PD
Shared or found resources to support mathematics instruction.	4	8	4	11	6	14	5	4
Solved or anticipated how my students might solve mathematics problems of a future lesson.	3	4	1	6	5	12	2	3
Modified preexisting lesson plans to meet the needs of my students.	3	4	1	8	3	9	2	3

Table 3.8 (continued).

Planned MTSS mathematics interventions.	0	3	0	2	4	5	0	0
Grouped students by perceived ability in mathematics.	1	3	0	5	4	7	3	1
Connected new mathematics content to previously taught content or to other subjects I teach.	2	4	1	6	4	6	4	2
Decided which mathematics manipulatives or games to use in a mathematics lesson.	4	7	1	11	6	14	3	4
Planned how technology could be used during mathematics lessons.	2	3	2	7	4	14	na	2

How to Teach Activities	**IC**	**PLC**	**V PLC**	**Plan**	**TC**	**LPR PD**	**DR PD**	**M PD**
Observed a mathematics lesson.	3	3	0	4	3	6	1	1
Watched a video of a mathematics lesson being taught by a teacher I did not know.	3	3	1	5	3	14	4	3
Watched a video of a mathematics lesson being taught by a teacher in my school.	1	0	0	0	1	0	0	0
Watched a video of a mathematics lesson I taught.	1	0	0	1	0	1	0	0
Practiced teaching mathematics lessons to students.	2	0	0	0	2	2	1	0
Practiced teaching mathematics lessons to other teachers.	2	2	0	1	1	2	1	0
Developed specific goals to improve my mathematics instruction.	5	2	1	5	3	5	2	1
Received feedback after a mathematics lesson observation.	5	0	0	2	2	5	1	0

Why Teach This Way Activities	**IC**	**PLC**	**V PLC**	**Plan**	**TC**	**LPR PD**	**DR PD**	**M PD**
Analyzed student mathematics work samples.	8	3	1	8	7	8	2	3
Analyzed mathematics work completed by the students in my class.	6	6	2	9	5	6	2	2
Listened to students explain their thinking.	5	0	0	1	4	6	2	1
Looked for resources that show how students' mathematical thinking progresses.	3	3	2	7	3	8	2	2
Discussed common solution strategies students might use to solve a mathematics problem.	7	4	3	5	6	9	2	3
Discussed common errors students might make when solving a mathematics problem.	7	4	2	6	5	11	2	3
Explored what models and tools would help students understand the mathematics content.	6	4	2	6	3	11	3	3

Table 3.8 (continued).

Matched lesson goals with grade-level mathematics Standards.	6	5	2	7	4	9	3	1
Used students' mathematics work to decide what to teach next.	7	4	0	7	5	6	1	1
I reflected on my mathematics instruction.	26	27	16	38	24	8	9	23
I reflected on the way I solve mathematics problems.	13	8	5	7	10	5	5	14
I reflected on the feedback I was given about my mathematics instruction.	12	10	7	12	7	3	6	5
I reflected on how my students understand the concepts.	22	30	8	35	18	9	9	17
I reflected on who I consider to be a good mathematics student.	8	5	3	9	7	6	3	10
I reflected on how I feel about learning mathematics.	9	5	2	7	6	5	3	10
I reflected on how I feel about teaching mathematics.	14	11	5	7	7	5	4	11
I reflected on the difference between how I solve a mathematics problem and how I teach mathematics.	13	12	3	10	10	5	3	12
I reflected on what it means to be a good mathematics teacher.	15	14	8	14	10	4	4	19

School Context

Data collected during the pilot test provided evidence that school context varies. Table 3.9 displays the responses that indicated yes to the corresponding items. For example, it was common for teachers to be provided with lesson plans (n=70) and less common for coaches to attend PLC meetings (n=8). This provided evidence the school context may influence PD opportunities. Therefore, the school context items can be used to describe teachers' experiences.

Table 3.9
School Context Items (Pilot Study)

School Context Items	Number of Responses that Indicated Yes
School Provided Standards (n=83)	56
School Provided Pacing Guide (n=80)	42
School Provided Lesson Plan (n=78)	70
School Provided Manipulatives (n=70)	70
School Provided a Daily Planning Period (n=60)	10
Principals Always or Frequently Attended PLC Meetings (n=50)	14
Coach Always or Frequently Attended PLC Meetings (n=50)	8
PLC Meeting Occur During Work Hours (n=49)	28

Conclusion

Data collected from expert reviews, cognitive interviews, and a pilot test was used to validate the TLO-M as a tool to quantify PD opportunities of elementary teachers. First, experts guided the creation of definitions and scoring and also confirmed the TLO-M content is appropriate for the intended purpose of reporting teachers' learning opportunities. Second, data from multiple rounds of cognitive interviews directed changes and confirmed the TLO-M items were understood as intended and matched teachers' experiences. Lastly, the pilot test confirmed that experiences align to the events and activities found in the literature. That is teachers participate in each type of PD and engage in WHWy activities during PD. Moreover, there was evidence that teachers have different opportunities and school support. Combined the data collected provided evidence of validity. Next, TLO-M scores are explained.

TLO-M Scores

An expert in teacher learning, mathematics education in the elementary grades, and measurement validity was consulted throughout the validation process as items became finalized and a scoring guide was developed. The TLO-M items are used to calculate three types of scores (See Table 3.10). First, frequency scores explain how often a teacher engages in the specific PD types (i.e., embedded, external, self-directed). Second, activity scores determine the presence of WHWy activities within the PD. Last, school context score describes circumstances that potentially support teacher learning. It is important to reiterate that scores do not evaluate PD opportunities. Therefore, high scores indicate more opportunities to participate in PD or WHWy activities. Each score is explained in detail next.

Table 3.10
TLO-M Scores

TLO-M Scores	Description	Range
Embedded Frequency Score (EMF)	The sum of PLC and coaching frequencies.	0-20
Embedded Activity Score (EMA)	The sum of PLC and coaching activity points.	0-10
External Frequency Score (EXF)	The sum of lesson plan resource PD, digital resource PD, and mathematics-focused PD frequencies.	0-15
External Activity Score (EXA)	The sum of lesson plan resource PD, digital resource PD, and mathematics-focused PD activity points.	0-15
Self-Directed Frequency Score (SDF)	The sum of the self-directed and social media networking frequencies.	0-20
School Context Score (SCS)	Total of 12 Possible Points (one point for each of the following): • Provided lesson plan resource • Provided Standards • Provided manipulatives • Provided pacing guide • Provided daily planning • School leaders (always or often) attending PLC • Coach (always or often) attending PLC • Curriculum coach focus on mathematics only • PLC occurs during work hours • Most teachers attend LRPD • Most teachers attend DRPD • Most teachers attend MFPD	0-12

Frequency Scores

Using a 0-5 scale, frequency scores are calculated for each type of PD (i.e., embedded, external, self-directed). As shown in Table 3.11, the embedded frequency score is the sum of four items that inquire about how often a teacher participates in PLC meetings and coaching opportunities. The external frequency score is the sum of three items that inquire about time spent in external PD. This includes resource focused PD (lesson plan resource and digital resource) and PD that is not resource focused which is referred to as mathematics-focused PD. Self-directed frequency is the sum of four frequency items which include how often teachers engage in self-directed activities during and outside of work hours and how often teachers use social media to network or find resources during or outside of work hours. It is important to note, the TLO-M utilizes skip logic so that teachers are only asked question that pertain to their experiences. For example, a teacher that is not provided with a lesson plan resource, will not be asked about lesson resource PD. For this reason, teachers will not have the same number of scores.

Table 3.11
TLO-M Frequency Items to Determine Scores

Purpose	Items	Response Options	Points for Score
Determine frequency of embedded PD	1. About how often did you receive individual coaching from a mathematics coach? 2. About how often did you receive team coaching from a mathematics coach? 3. About how often did you participate in grade-level mathematics PLC meetings? 4. About how often did you participate in vertical mathematics PLC meetings?	0=never 1=a few times per year 2= about quarterly 3= about monthly 4=about weekly 5= about daily	0-5 on each item
Determine frequency of external PD	1. About how often did you attend lesson plan resource professional development? 2. About how often did you attend digital resource professional development? 3. About how often did you attend mathematics professional development?	0= none 1= up to 3 hours 2= 3-8 hours 3=9-12 hours 4=13-19 hours 5=20 or more hours	0-5 on each item

Table 3.11 (continued).

Purpose	Items	Response Options	Points for Score
Determine frequency of self-directed PD*	1. About how often did you engage in self-directed learning activities during the school day to support your 2018/19 mathematics instruction? 2. About how often did you engage in self-directed learning activities after work hours to support your 2018/19 mathematics instruction? 3. About how often did you access social media during the school day to support your 2018/19 mathematics instruction? 4. About how often did you access social media after work hours to support your 2018/19 mathematics instruction?	0=never 1=a few times per year 2= about quarterly 3= about monthly 4=about weekly 5= about daily	0-5 on each item

Note. *Self-directed items included a list of examples (e.g., reading a book, listening to a podcast, attending a mathematics conference).

Activity Scores

Activity points are calculated for embedded and external events. Table 3.12 shows the five groups of activity items that inquire about participation in WHWy activities. The group of activity items are asked several times throughout the survey. The TLO-M utilizes skip logic so that the items are only asked after a teacher indicates participating in (1) PLC meetings, (2) coaching, (3) Lesson Plan Resource PD, (4) Digital Resource PD, and (5) Math-Focused PD. This means the activity items could be asked up to five times. Notice activity points are given per section not per item. For example, a teacher will earn one point for answering yes to all or to only one of the seven items in the What to Teach section. Although the specific activities provide useful information, they are not used to determine the score. This decision is based on the recommendation that PD incorporates a mix of WHWy activities (National Research Council & Mathematics Learning Study Committee, 2001). In other words, the combination of WHWy activities may increase the potential learning of the experience. Activity points for any given PD range from 0-5. It is important to note, due to the use of skip logic, not all teachers will be asked the same activity items. This is because the How to Teach (student perspective) item is the first activity item which also acts as a filter question. As shown on Table 3.12, it is the only multiple-response activity item. One response is used to indicate How to Teach (student perspective) and another determines if the other activity items will follow. Specifically, if the teacher indicates a lecture-style PD, no additional activity items will be asked about that experience.

Table 3.12
TLO-M Activity Items to Determine Scores

Purpose	Items	Response Options	Points for Score*
Determine participation in What to Teach activities	1. Did you prepare materials to use during instruction? 2. Did you find, create, or share mathematics resources? 3. Did you modify preexisting lesson plans to meet the needs of your students? 4. Did you solve mathematics problems you planned to use during instruction? 5. Did you connect new mathematics content to previously taught material? 6. Did you decide which mathematics manipulatives or games to use during instruction? 7. Did you plan instruction that connected to your students' lives outside of school?	0=no 1=yes	0 or 1 zero points if responses are all no
Determine participation in How to Teach activities	1. Which best describes the type of participation you experienced?	○ One person shared information. Others listened and asked questions. • **One person modeled how to teach by taking the role of a teacher. Others engaged in the lesson as students.** ○ Participants collaborated and engaged in activities together.	0 or 1 1 point if bolded option is selected
Determine participation in How to Teach activities	1. Did you watch someone else teach mathematics? (live or video) 2. Did you practice an instructional method by teaching students or other teachers? 3. Did you develop specific goals to improve your mathematics instruction? 4. Did you receive feedback about your mathematics instruction?	0=no 1=yes	0 or 1 zero points if responses are all no
Determine participation in Why Teach This Way activities	1. Did you analyze students' mathematics work? 2. Did you listen to students explain their thinking (live or video)? 3. Did you look for resources that show how students' mathematical thinking progresses? 4. Did you look at common solutions, strategies, and errors students might use to solve a mathematics problem? 5. Did you explore what models and tools would help students understand the mathematics content?	0=no 1=yes	0 or 1 zero points if responses are all no

Table 3.12 (continued).

	6. Did you match lesson goals with grade-level Standards? 7. Did you use students' mathematics work to decide what to teach next?		
Determine participation in Why Teach This Way activities	1. Were you asked to reflect upon how you feel about learning or teaching mathematics? 2. Were you asked to reflect upon the difference between how you solve mathematics problems and how you teach students to solve mathematics problems? 3. Were you asked to reflect upon feedback given to you about your mathematics instruction? 4. Were you asked to reflect upon how well your students understand mathematics concepts? 5. Were you asked to reflect upon how you define a good mathematics student or an effective mathematics teacher? 6. Were you asked to reflect upon how racial, ethnic, linguistic, gender, and socioeconomic status do not determine the ability to learn mathematics?	0=no 1=yes	0 or 1 zero points if responses are all no

Note. * Notice activity points are given per section not per item. For example, a teacher will earn one point for answers yes to all or to only one of the seven items in the What to Teach section.

School Context Score

The school context score (SCS) is calculated from the school context items. The SCS can range from 0-12 with one point given for each of the following (1) school provides a lesson plan resource, (2) school provides Standards, (3) school provides manipulatives, (4) school provides a pacing guide, (5) teacher is provided with daily planning, (6) school leaders (always or often) attend PLC, (7) coaches (always or often) attend PLC, (8) curriculum coach focus on mathematics only, (9) PLC occurs during normal work hours, (10) most teachers attend lesson resource PD, (11) most teachers attend digital resource PD, and (12) most teachers attend mathematics-focused PD. Considering that the qualitative portion of this study focuses on embedded PD, the SCS discussed in chapter 5 will range from 0-9 because it excludes the three items that refer to external PD. Table 3.13 list the TLO-M items used to determine the school context points.

Table 3.13
TLO-M School Context Items

Purpose	Items	Response Options
Determine Resources	How were you provided access to the mathematics Standards during the 2018/19 school year? (choose all that apply)	• **My school provided me with this resource.** ○ I was provided time during the workday to create or find this resource. ○ I was not provided this resource or time during the school day to find or create this resource.
	How were you provided access to a mathematics pacing guide during the 2018/19 school year? (choose all that apply)	• **My school provided me with this resource.** ○ I was provided time during the workday to create or find this resource. ○ I was not provided this resource or time during the school day to find or create this resource.
	How were you provided access to mathematics lesson plans during the 2018/19 school year? (choose all that apply)	• **My school provided me with this resource.** ○ I was provided time during the workday to create or find this resource. ○ I was not provided this resource or time during the school day to find or create this resource.
	How were you provided access to mathematics manipulatives during the 2018/19 school year? (choose all that apply)	• **My school provided me with this resource.** ○ I was provided time during the workday to create or find this resource. ○ I was not provided this resource or time during the school day to find or create this resource.
	Did the coach provide support for other subjects (e.g. English Language Arts, Science, Technology)?	○ Yes • **No**
Determine School Leader Participation in PLC Meetings	Which best describes how often a mathematics coach participated in PLC meetings?	• **Always** • **Frequently** ○ Sometimes ○ Seldom ○ Never
	Which best describes how often school leaders (e.g., principals, assistant principals) participated in PLC meetings?	• **Always** • **Frequently** ○ Sometimes ○ Seldom • Never

Table 3.13 (continued)

Determine message alignment	Which best describes the time of day PLC meetings normally took place?	• **During your scheduled work hours (e.g., between 7:45 am and 3:30 pm)** ○ Before or after your scheduled day ○ A combination of both
	Which best describes the teachers that participated in the 2018/19 lesson plan resource PD?	• **Most of the teachers in my school participated.** ○ A select group of teachers from my school (e.g., first-year teachers, grade-level chairs) participated. ○ I was the only teacher from my school that participated.
	Which best describes the teachers that participated in the 2018/19 digital resource PD?	• **Most of the teachers in my school participated.** ○ A select group of teachers from my school (e.g., first-year teachers, grade-level chairs) participated. ○ I was the only teacher from my school that participated.
	Which best describes the teachers that participated in the 2018/19 digital resource PD?	• **Most of the teachers in my school participated.** ○ A select group of teachers from my school (e.g., first-year teachers, grade-level chairs) participated. • I was the only teacher from my school that participated.

Note. The school context score can range from 0-12 with one point given for each of the bolded items in the response option column.

Rationale for Scores

To exemplify the importance of considering both the frequency of PD as well as the activities that occur during PD, consider the possible experiences of two teachers. Table 3.14 demonstrates how two teachers with the same frequency score might have very different experiences. Beth engages in more WHWy activities than Sarah. Although, the TLO-M does not determine the quality of PD, it is likely that Beth's experience provides more potential to learn about Standards-based instruction. This provides evidence that activity scores provide valuable information about teachers' PD experiences.

Table 3.14
The Experiences of Two Teachers

Teacher	Frequency Points	Activity Points
Beth	PLC Frequency Points=6 points Teacher attends grade-level PLCs weekly (4 points) and vertical PLCs quarterly (2 points).	Activity Points= 4 points Beth meets weekly with grade-level PLCs to determine how the textbook lesson might be modified to meet the needs of the students in their classes (1 point for What to Teach). This includes anticipating how students will solve and planning questions to prompt student thinking (1 point for Why Teach this Way (student learning)). They also agree upon common formative assessments that will provide information about student learning and then reflect upon the data after the assessment is given (1 point for Why Teach this Way (reflection)). During vertical PLCs, the school mathematics coach models instructional strategies by facilitating a problem-solving lesson (1 point for How to Teach (student perspective)). After the lesson, teachers discuss how students at various grade levels might think about the same problem.
Sarah	PLC Frequency Points=6 Teacher attends grade-level PLCs daily (5 points) and vertical PLCs one time per year (1 point)	Activity Points= 1 Sarah meets daily with a grade-level PLC to choose a worksheet to use for homework (0 points). About one time a week, the team meets for an extended period to share resources (1 point for What to Teach). During vertical PLCs, the mathematics coach explains the standardized test data (0 points).

Looking at both scores provides a better understanding of teachers' PD experiences. Consider what the two scores might reveal about coaching opportunities (See Table 3.15). Amy works with a coach for an entire day at the beginning of the school year (one frequency point). The day includes activities from each of the WHWy categories (five activity points). In this case the activity points are high but there is not enough time committed to learning. In comparison, Sam meets with a coach to plan instruction daily during the planning period. The time is spent preparing the materials needed for class on the following day. In this case, there is a lot of time spent with a coach, but the opportunity is limited due to the narrow focus. For this reason, it is important to consider both the frequency and activities when understanding teachers' experiences.

Table 3.15

Coaching Points for Two Teachers

Teacher	Coaching Frequency Points	Coaching Activity Points
Amy	1 point	5 points
Sam	5 points	1 point

Part Two: The Main Study

Research Design

The overall dissertation study used a mixed-methods approach that collects and analyzes both quantitative and qualitative data (See Figure 3.7). A mixed-methods approach allows for a more complete picture of teachers' learning opportunities (Creswell, 2012). In this research, the TLO-M survey was used to collect quantitative data from elementary teachers in one district, presented as an article to be submitted to *Journal for Research in Mathematics Education* (Chapter 4). The chapter reports on teachers' learning opportunities in mathematics in the district and the relationship between those learning opportunities and other variables like the school context. A second article to be submitted to *Journal of Mathematics Teacher Education* (Chapter 5) reports quantitative and qualitative data using a sequential mixed methods design (quan → QUAL; Creswell & Plano Clark, 2017). By analyzing the quantitative data from the survey collected in the first phase, two schools were purposefully selected for the follow-up, qualitative phase of the study. Choosing two schools allowed for a better understanding of the learning opportunities of the elementary teachers in the district (Gustafsson, 2017). Although it is more common for quantitative data to be given priority in studies that utilize an explanatory design (Creswell & Plano Clark, 2011), Chapter 5 will emphasize the qualitative data of the multiple case study.

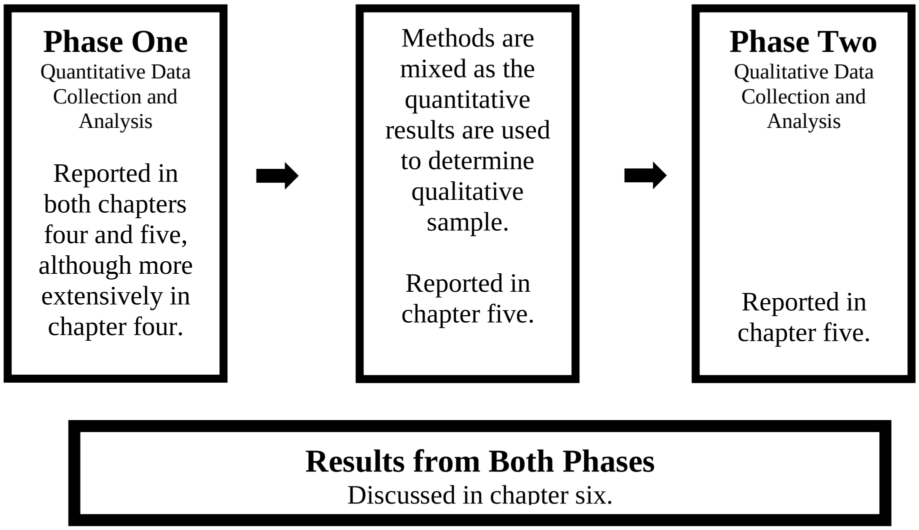


Figure 3.7. Explanatory sequential design of the study.

Context

A partnership with a school district in the southeastern United States was made by meeting with the director of research and the director of PD. A proposal was shared with the district and approved by the district cabinet (Appendix F). The district agreed to endorse the study by encouraging all elementary teachers and principals to participate. The district includes schools that serve suburban towns on one side to much more rural areas on the other side. There are approximately 37,000 students in the district at 45 schools (i.e., 23 elementary schools). An increase in population has doubled the number of students in the district over the past 15 years. Students are ethnically diverse (52% White, 25% Hispanic, 16% African American, 5% multiracial, and less than 1% Native American and Pacific Islanders) and represent 69 different countries.

Data Collection and Procedure

To understand elementary teachers' learning opportunities focused on mathematics, the TLO-M was used to collect the quantitative data from teachers during Phase 1 and interview and document data from school leaders during Phase 2. Next, the data collection and procedure are explained for each phase.

Phase 1: Participants

In Fall 2019, an email list was provided by the district and used to send 1,319 elementary school employees information about the study and solicit participation. The email included a link to the TLO-M. As an incentive to complete the survey, which took about 10-20 minutes, participants were eligible to enter a drawing for one of thirty-five $15 gift cards. The link remained active for seventeen days with reminders being sent on day two, seven, and sixteen. School principals were sent emails to encourage participation two times during data collection. The first section of TLO-M items established consent to participate and determined participant eligibility. This means data was collected from teachers that (1) agreed to participate, (2) was employed by the district during the 2018/19 school year, (3) taught mathematics to K-5, and (4) was not a special education teacher. Six-hundred thirty teachers were estimated to be eligible by subtracting the district's average turnover from the number of mathematics teachers per school. Although 280 teachers started the survey, data were only collected from 174 teachers. This means data were not collected from 106 teachers that (1) did not agree to participate, (2) did not meet participant eligibility criteria, or (3) ended the survey before answering TLO-M items. In short, there was a 28% response rate which is typical for a web-based survey (Nulty, 2008).

The sample was primarily female (98%) and represented each grade level (20% kindergarten, 17% first-grade, 16% second-grade, 18% third-grade, 17% fourth-grade, 11% fifth-grade). Teachers were at various stages of their career, with 26% having taught less than five years, 40% having taught between five and fourteen years, and 33% having taught more than fifteen years. Forty-one percent of the participants reported working at their current school for less than five years. See Table 3.16 for the complete demographic characteristics of the sample.

Table 3.16
Descriptive Characteristics of Phase 1 Participants

		Number of Teachers
Age (years)	Under 25	4
	25-39	75
	40-59	53
	60 or more	3
Teaching Experience (years)	Less than 5	33
	5-14	62
	More than 15	42
Years Teaching at School	Less than 5	72
	5-14	51
	More than 15	13
Grade	Kindergarten	30
	First	28
	Second	34
	Third	30
	Fourth	27
	Fifth	20
Degree	Bachelor’s	105
	Master’s	31
Elementary Mathematics License	Yes	8
	In the process	1
	No	128

Note. Information on table reports data collected from the participants that answered demographic items.

Phase 1: Quantitative Data Collection

TLO-M. The TLO-M was used to collect data from teachers. The 81-item web-based survey include items that inquire about frequency of PD participation, activities that occur during PD, and school context. Examples of TLO-M items are shown in Figure 3.8. The data collected were used to calculate frequency, activity, and school context scores. Due to the utilization of skip logic, data collected from each participant varies and not all participants have all scores. For instance, a teacher that did not attend external PD will not have external PD scores.

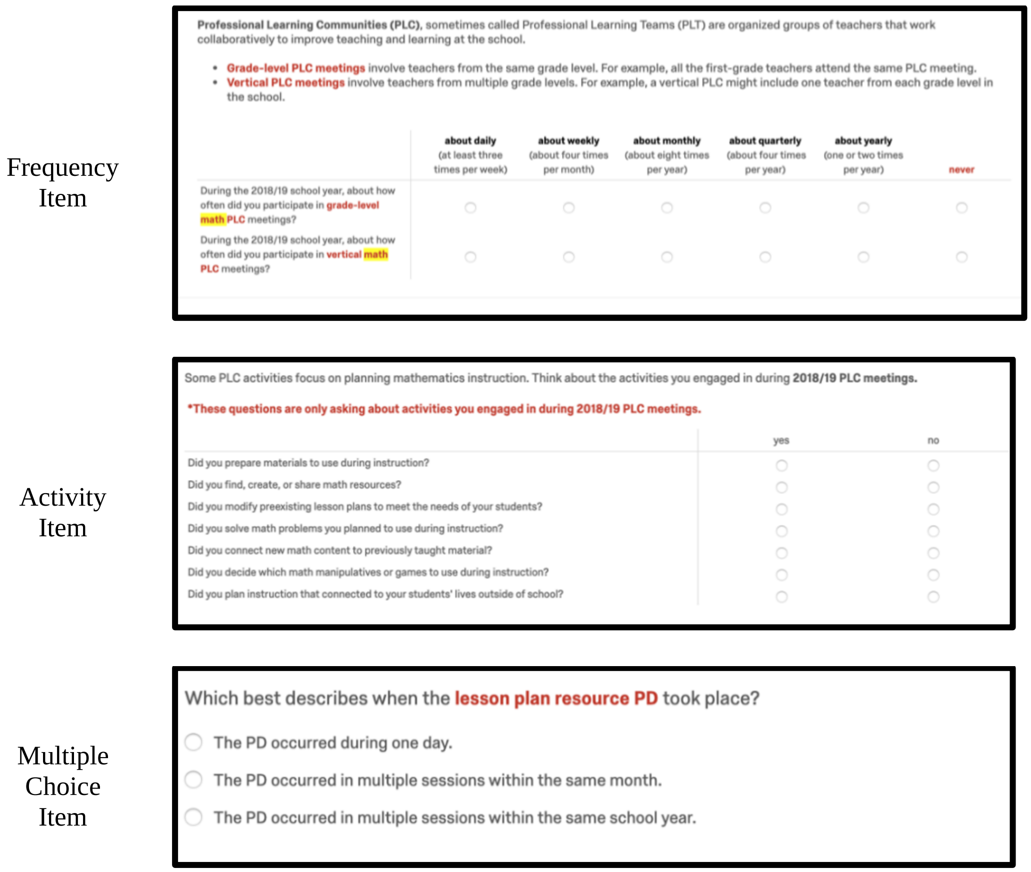


Figure 3.8. TLO-M example items.

Phase 1: Quantitative Analysis

The survey data was uploaded to SAS Studio to be cleaned and analyzed. First, the data were examined for quality (e.g., check to make sure data were in expected range, look for missing data) and inspected for errors (e.g., summary statistics, visualizations). Then, the data were manipulated to prepare for analysis (See Table 3.17). This included creating variables needed to calculate scores.

Table 3.17
Data Manipulation Prior to Analysis

Creation of New Variables

1. Created variable *id* (id for each case)
2. Create variable *access* (one point for each resource provided: lesson plans, Standards, manipulatives, pacing guide)
3. To create PLC Scores:
    a. Created variable *plcactscore*
    b. Created variable *combinedplc* (sum of two frequency items: grade-level PLC and vertical PLC)
4. To create Coaching Score:
    a. Created variable c*actscore*
    b. Created variable *combinedcoach* (sum of two frequency items: individual coaching and team coaching)
5. To create Embedded Scores:
    a. Created variable *emfr* (combinedplc + combinedcoach)
    b. Created variable *emac* (plcactscore + cactscore)
6. To create Lesson Plan Resource PD Scores:
    a. Created variable *pd1actscore*
    b. Created variable *pd1freq*
7. To create Digital Resource PD Scores:
    a. Created variable *pd2actscore*
    b. Created variable *pd2freq*
8. To create Math-Focused PD Scores:
    a. Created variable *pd3actscore*
    b. Created variable *pd3freq*
9. To create External Scores:
    a. Created variable *exfr* (pd1freq + pd2freq + pd3freq)
    b. Created variable *exac* (pd1actscore + pd2actscore + pd3actscore)
10. To create School Context Score (*SCS*):
    a. Created variable *onlymathcoach* (reverse coded item asking if coach supported other content areas; 1=coach was mathematics focused)
    b. Created variable *plctime* (1=PLC meetings occurred during the school day)
    c. Created variable *plccoachsupport* (1= participant indicated that a coach always or frequently attended PLC meetings)
    d. Created variable *plcleadersupport* (1= participant indicated that admin always or frequently attended PLC meetings)
    e. Created variable *plan* (1=participant indicated daily planning period was provided)
    f. Created variable *pd1pscs* (1=participant indicated most teachers at school participated in lesson plan resource PD)
    g. Created variable *pd2pscs* (1=participant indicated most teachers at school participated in digital resource PD)
    h. Created variable *pd3pscs* (1=participant indicated most teachers at school participated in mathematics-focused PD)
    i. Created variable *SCS* (sum of access, plctime, onlymathcoach, plccoachsupport, plcleadersupport, pd1pscs, pd2pscs, pd3pscs, plan)
11. To Create Self-Directed Score:
    a. Created *sddw* (sum of self-directed activities during work hours and social media use during work hours)
    b. Created variable *sdaw* (sum self-directed activities after work hours and social media use after work hours)
    c. Created *SDLS* (sddw + sdaw)
12. Used public data to create variable *title1* (1=title1 status)
13. Created variable *degmd* (1=participant indicated having master's degree)

Table 3.17 (continued).

14.	Created variable *msld* (1=participant indicated having or in the process of earning an elementary mathematics specialist license)
15.	Created variable *moremath* (1=teacher taught mathematics to more than one class; departmentalized)
16.	Created variable *teachless5* (1= participant indicated less than five years of teaching experience)
	Created variables for school means

Descriptive statistics were used to answer the first question: How do teachers working in the same school district view their opportunities to participate in mathematics focused PD and how do the reported experiences compare? Specifically, frequencies and activities were tabulated, and teacher and school scores were calculated.

Next a stepwise method regression was conducted to answer the second research question: What is the relationship between mathematics-focused learning opportunities and other factors (e.g., grade level, years of experience, school contextual factors)? This type of regression starts with no variables and then goes through a process of testing each variable one by one to determine the best fit model. This means that only significant variables are included this type of model (NCSS, 2017). Regression was determined to be appropriate after verifying the data met regression assumptions (Chen, Ender, Mitchell, von Eyben, & Wells, 2004). Specifically, it was determined that outliers did not significantly change the results of the regression, t-test showed linear relationship between the PD scores and other variables (e.g., departmentalized, school-context score), and a White test showed the residual was homogenous. Moreover, Chi-Square Goodness of fit test determined the sample had a similar percent of teachers with a master's degree and elementary mathematics specialist (EMS) license. An EMS earns credentials to be specialized in teaching mathematics. It is important to note that 22% of the teachers in the sample had a master's degree, which is less than the reported state percent (33%) of elementary teachers with a master's degree (NCTS, 2011). However, in 2013 the state stopped compensating teachers with a master's degree, so it is possible the percent of teachers with a master's degree decreased. Therefore, I made the decision to keep master's degree as a predicter. Furthermore, there is very little published information about the number of teachers with EMS licensure (McGatha, 2017). Research from a neighboring state reported about 4% of teachers at medium size school districts are EMS (Markworth, Brobst, Ohana, & Parker, 2016). This information justified the decision to use EMS as a predictor. The stepwise method is a common procedure used to create the most predictive model by considering the significance of each variable one at time (Marasinghe, & Koehler, 2018). However, stepwise will not produce the best model if there are redundant predictors. Therefore, to avoid overfitting, not all predictor variables were included in the regression (Babyak, 2004). For example, there was a correlation between grade-level and departmentalized, so grade-level was not used in the model. More information about the models are described in the methods section of Chapter 4.

Phase 2: Participants

This study used sequential explanatory participant selection in which participants for the second phase were determined after analyzing the quantitative data in phase one (Creswell & Plano Clark, 2007). Descriptive statistics were analyzed to identify two schools to investigate further. For a school to be considered for phase two, 25% or more of the school's eligible teachers needed to participate in phase one. Teachers' embedded activity scores (EMA) and school context score (SCS) were used to create school means for ten schools that met the eligibility. EMA and SCS were used because the results of Phase 1 showed a significant positive relationship between the two. In other words, as SCS increased, EMA also increased. This finding suggests that the more a school supports mathematics teaching and learning the more opportunities teachers have to participate in WHWy activities. Therefore, it could be assumed that schools with higher SCS would have a higher EMA. However, that was not the case for all of the schools. The boxplot in Figure 3.9 shows the distribution of teachers' SCS per school. The circled numbers indicate the three schools that fell in the fourth quartile when school averages were compared. Notice schools one, nine, and nineteen are circled. In theory, the same schools should have the highest EMA scores which holds true for schools one and nineteen. In contrast, school nine had the second lowest EMA scores of the ten schools being compared. For this reason, school nine was chosen as a school to further investigate. School one was chosen as the other school. Both chosen schools have a high SCS and contrasting EMA scores. It is important to note that school 19 was not chosen because of the researcher's previous employment at the school. Pseudonyms were given to school one and nine and will be used throughout the dissertation (school 1=Madison Elementary, School 9= Lincoln Elementary). Table 3.18 shows additional information used to support the case selection (i.e., size and Title1 status).

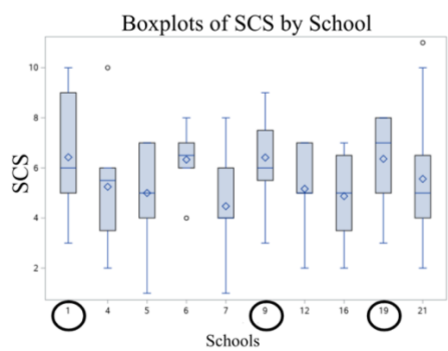


Figure 3.9. *Boxplots of SCS by school. The circled numbers indicate the schools with the highest SCS mean.*

Table 3.18
Characteristics of Schools

	School 1 Madison Elementary	School 9 Lincoln Elementary
Percent of Teachers that Participated in Phase 1	33%	60%
School’s Average SCS	6.43	6.42
School’s Average EMA	2.00	3.14
Number of Students	630	570
Title1 Status	Yes	Yes

An email was sent to the principals of the two schools chosen for Phase 2. Assistant principals (AP) and curriculum coaches were emailed after principals agreed to participate. Due to a new AP at Madison Elementary, the former AP (still working in the district) was invited but declined the offer to participate. For that reason, interview data was collected from a principal, AP, and coach of Lincoln Elementary and a principal and two coaches from Madison Elementary.

Phase 2: Qualitative Data Collection

Semi-structured interviews. The researcher met with each participant at a scheduled time to conduct a semi-structured interview (Appendix L) during the months of October and November 2019. A semi-structured format was used to collect data from school leaders. The format is flexible enough to probe individuals on their perspective yet provides a level of consistency throughout the interviews (Merriam & Tisdell, 2016). The interview questions focused on mathematics instruction including questions about provided resources, expectations, PLC meetings, coaching opportunities, and external PD. The same questions were asked of each participant. However, the conversation guided additional prompts. Interviews were conducted in person and lasted between 55 and 80 minutes. Interviews were audio-recorded and transcribed by the researcher.

School improvement plan. According to state law followed by the district, schools are required to participate in the School-Based Management and Accountability Program. This includes designating a team of school members to develop a School Improvement Plan (SIP). The SIP was collected for data because it is likely to provide information about school initiatives. The SIP was obtained at the time of the interview with the school principal.

Phase 2: Qualitative Analysis

Interview data and the SIP were analyzed to answer the second research question: What additional information can school documents and interviews with school leaders provide when trying to understand teachers' embedded learning opportunities?

Analyzing qualitative data is an iterative process (Creswell, 2018). This means making sense of the data is a continuous process that includes coding and reading several times. The process started by writing a memo after each interview. The purpose of the notes was to capture initial thoughts and wonders. For example, one memo reads, "The principal seems to believe that change will take time and only expects a little bit at a time. It was difficult for him to only talk about mathematics. Maybe because he is trying to leverage the reading curriculum to bring attention to the mathematics curriculum."

The next step was transcribing the interviews to begin the coding process. Figure 3.10 shows a visual model of the coding process (Creswell, 2018) and can be used to explain the method I used to analyze the data. After reading through the Lincoln Elementary transcripts, the interviews were sectioned by the interview question. Each section was coded sentence by sentence (See column one on Table 3.19). Then the list of initial codes were grouped (e.g., PLC meetings, PLC activities) and repetitious codes (e.g., textbook, Investigations) were deleted (See column two on Table 3.19). The reduced codes were sorted into four sections (1) School Characteristics and Culture, (2) Teacher PD Opportunities, (3) Goals/Vision, and (4) Changes. Then the interviews for case one and case two were coded using the codes in the four sections. Lastly broad themes (See column three on Table 3.19) were determined.

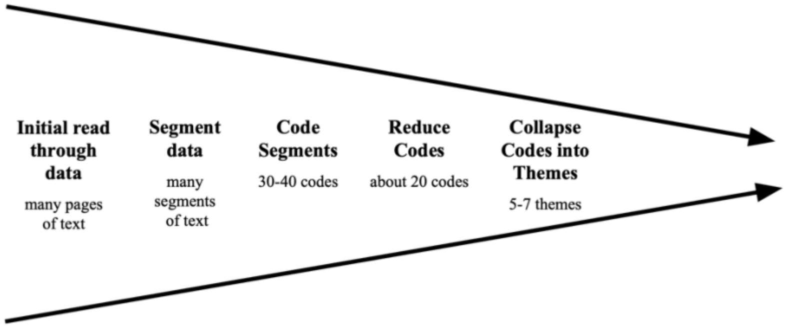


Figure 3.10. A visual model of the coding process in qualitative research (adapted from Creswell and Gutterman, 2018).

Table 3.19

The Coding Process (Using the Creswell and Gutterman (2018) Model)

Initial Codes	**Four Categories of Collapsed Codes** reduced overlap and redundancy	**Theme** collapse codes into themes
• Materials • Textbooks • PLC schedule • PD schedule • Manipulatives • Provided Resources • School-wide PD • Supplement resources • Standards • Formative Assessment	**PD Opportunities** **The school leader describes PD:** • description of PLC meetings (frequency, attendees, roles, activities, outcomes) • description of coaching activities (frequency, participants, goals, outcomes) • description of PD (participants, purpose, frequency, outcomes) • description of resources (purpose, expectation of use, perceived use, missing) **The school leader describes their own beliefs:** • description of PD (useful, not useful) description of quality of resources (good, not good)	Schools support teaching and learning of mathematics through the schedule, coaching, resources, and external PD.
• School initiatives • District initiatives • Empower teachers • Develop teachers' mathematics knowledge • Align instruction with standards • Use formative assessments to guide discussions • Increase collaboration	**Goals/Vision** **The school leader describes goals:** • description of school initiatives (reason, accountability, progress, outcomes) • description of school vision (what, how is it being reached, differences in former expectations)	The school's vision influences the PLC and Coaching Activities.

Table 3.19 (continued).

• Change community • Build trust	**The school leader describes their own beliefs:** • description of beliefs about how people learn • description of what he/she values, or think is important	
• conversations in PLC meetings • expectations of PLC • expectations of coaching • role of leaders • personalities of teachers • strength and weakness • More time on ELA • Reasons teachers lack mathematics knowledge and confidence • Class activities observed in mathematics	**School Characteristics and Community** **The school leader describes the school and community:** • description of the school (location, demographics) • descriptions of communication and relationships (between teachers, between leaders, between teacher and leaders, etc.) • description of how expectations are communicated (verbal and nonverbal) • description of how roles are implemented (teacher, coach, principal, leadership team) **The school leader describes their own beliefs:** • description of teacher (perceived knowledge, instruction, characteristics, strengths, weaknesses, personalities) • description of students (perceived knowledge, instruction, characteristics, strengths, weaknesses, personalities)	Schools have unique circumstances which influence PLC and coaching activities.
• student behavior • student achievement • student engagement • mathematics instruction • PLC conversations • Coaching conversations • Roles of school leaders • Change in Expectations	**Changes** **The school leader describes changes:** • description of change (teacher change, instruction change, behavior, attitudes) • description of data change (student, school) **The school leader describes their own beliefs:** ○ description of why changes occur (roles, change in admin)	Learning is a process that takes time.

The purpose of this chapter was twofold. First, this chapter presented information that justified the TLO-M as a valid instrument to use when determining elementary teachers' PD opportunities. Second, methodology used for the main study was described. As mentioned previously, chapters 4 and 5 are written as two almost-ready-to-submit journal articles with

Chapter 4 reporting the quantitative results and Chapter 5 reporting the qualitative results. Due to this layout it is necessary for some information previously presented in chapters 1-3 is repeated in chapters 4 and 5.

CHAPTER 4: QUANTITATIVE RESULTS

Journal

This article is written as a report to be submitted to the *Journal for Research in Mathematics Education (JRME).* The maximum length for a research report is 12,000 words (excluding references, tables, and figures). The journal seeks research that contributes knowledge to the field of mathematics education.

Abstract

Implementing the Common Core Standards for Mathematics (CCSS-M) requires teachers to have specialized knowledge and skills. For this reason, national, state, and local funds are allotted for teacher professional development (PD). Therefore, it is likely many teachers participate in PD aimed to improve their mathematics instruction. This study explains elementary teachers' mathematics-focused PD opportunities with data collected from 174 teachers working in 23 schools in the same district. Quantitative results showed that teachers had significantly different opportunities. Some of the variation is explained by school context and teacher characteristics including being departmentalized, having a master's degree, and having or being in the process of obtaining an elementary mathematics specialist license.

Introduction

The National Council of Teachers of Mathematics (NCTM) (2014) supported the creation and implementation of the Common Core State Standards for Mathematics (CCSS-M). At first glance, the CCSS-M may seem similar to sets of previous state standards because they each set grade-level expectations. However, previous state standards and the CCSS-M are very different. Previous standards were more like a list of grade-level topics teachers should cover, which made it seem like mathematics is many disconnected topics. In contrast, the CCSS-M seeks students to develop deep mathematical understandings by intentionally leveraging the connectedness of mathematics including the vertical progressions of topics/standards across grade levels that in most cases reflect research-based trajectories of children's learning. For example, instead of place value, addition, and subtraction as separate topics, students would use their understanding of place value to develop addition and subtraction strategies. Equally important, the CCSS-M includes practice standards that are described as the "expertise educators at all levels should seek to develop in their students" (CCSS-M, 2010). Consequently, instruction should also be different and move away from lecture-style classrooms where the teacher tells and shows students what they need. However, facilitating student-centered lessons requires a deep understanding of content (Hirsch, Lappan, & Reys, 2012; Ball, 2003). For these reasons, the launching of the CCSS-M brought attention to the need for teacher professional development (PD) and support from all stakeholders to understand these new standards and see the value of their implementation (Sztajn, Marrongelle, Smith, & Melton, 2012).

Although not exclusive to mathematics, educational policies support PD. An estimated $20 billion of local, state, and national funds is spent on PD each year (Guskey & Yoon, 2009). According to the US Department of Education, Title II provides funds for evidence-based PD intended to improve teacher quality; however, little is known about the outcomes. In addition, little is known about the majority of PD provided to teachers due to most opportunities being locally planned and implemented (Sztajn, 2011).

Professional development (PD) provides in-service teachers with opportunities to develop their practice. Desimone (2009) discussed "what counts as professional development" and refers to a "vast range of activities and interactions that may increase [teachers'] knowledge and skills and improve their teaching practice" (p. 182). Likewise, there are also many terms used to describe these activities and interactions (e.g., teacher learning, professional learning, staff development). For clarity in this study, *PD* will be used to refer to all events in which teachers have the opportunity to learn about the mathematics they teach. *Activities* will refer to what teachers do during PD. For example, analyzing student work is an *activity* a teacher might engage in during PD. Next, the literature review will first discuss types of PD and then the activities teachers engage in during PD.

Types of PD

Darling-Hammond, Hyler, and Gardner (2017) call for PD to shift from external one-shot workshops to an embedded design that situates learning opportunities in teachers' work. Using this explanation, embedded PD could be thought of as experiences that are integrated into daily practice (e.g., team planning) while external opportunities are not (e.g., workshops or conferences). *Embedded PD*, the first type of PD of interest in this study, is part of a teacher's normal routine. This means the learning experience is ongoing and occurs at the school. In contrast, external PD is outside the normal routine. This means it happens away from the school with the frequency of sessions ranging from one to many. *External PD* is the second type of PD investigated in this study. A review of the literature, that is described below, indicated that some learning opportunities are neither embedded, nor external, and warrant the naming of a third type of PD. *Self-directed PD* can happen during or outside the workday and include activities in which a teacher participates or initiates independently. Often, these learning opportunities have no connection to a school (e.g., teachers supporting one another via social media).

When classifying PD by type as described in the literature, there was additional evidence that the type of PD could be further sorted by events. Figure X displays how teacher PD can be sorted in three types (embedded, external, self-directed) and further defined by events (e.g., planning period, PLCs, coaching) that fit under each type. A description of types and events follows.

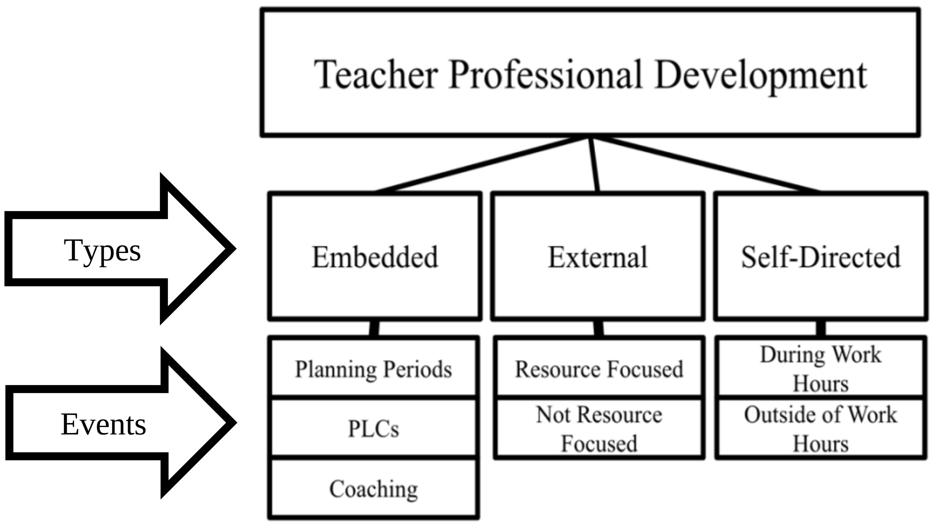


Figure 4.1. *Types of professional development and events within each type.*

Embedded PD

Embedded PD occurs during the typical school day. There is evidence in the literature of embedded PD taking place during shared planning periods, while meeting with Professional Learning Communities (PLC), and while being coached.

***Shared planning periods*.** Many elementary teachers have a planning period built into their daily schedules (NCES, 2012). This provides time to address responsibilities such as preparing for lessons and communicating with parents. Sometimes planning periods are used to collaborate with other teachers. In a systematic review of the literature, Vangrieken, Dochy, Raes, and Kyndt (2015) concluded that opportunities to collaborate could have positive impacts such as reducing teacher isolation and increasing teacher motivation and efficacy. Although teachers might not have the recommended ten hours per week (Wei, Darling-Hammond, Andree, Richardson, and Orphanos, 2009), there is evidence that teachers are provided time to work together. Using a national sample of 3,328 public school teachers, Rentner, Kober, Frizzell, and Ferguson (2016) reported that most teachers have opportunities to collaborate with others that teach the same grade level or content. However, the same teachers think additional planning and collaboration time would improve their day-to-day work. Similarly, in a study seeking to understand co-teaching, Fennick and Liddy (2001) found that many special education and classroom teachers responsible for co-teaching are not provided enough joint planning time.

Providing teachers with planning time might be especially beneficial to novice teachers (Wood & Weasmer, 2004). In one example, Bauml (2014) reported that collaborating with other teachers during the planning period had positive effects on a new teacher's mathematics instruction. The author said the teacher used the time to ask her teammates questions about school procedures and materials (e.g., testing, pacing guide) as well as questions about instruction (e.g., how to teach). The teacher credited the support she had during this time to her success with mathematics instruction.

Professional learning communities. Professional Learning Communities (PLC), sometimes called Professional Learning Teams (PLT), also provide teachers time to collaborate. According to DuFour and DuFour (2013), there are specific characteristics that differentiate PLC meetings from other situations in which teachers work together. Specifically, PLCs imply a collegial setting where teachers focus on specific goals to improve student learning. This means PLC meetings are much more intentional than a casual conversation around mathematics. The idea of teachers learning in this type of environment is not exclusive to PLCs. For instance, Wegner (1998) described situated learning that happens in communities of practice. In the case of teaching, this would mean teachers improve their instruction by meeting with other teachers to discuss their practices. For instance, this occurs when teachers engage in a lesson study, which includes planning together, observing each other teach, and reflecting together. Critical Friend groups are another method used to develop teaching practice through collaboration by teachers helping each other devise solutions for their problems (Darling-Hammond & McLaughlin, 1995). When examining teachers participating in critical friend groups, Kuh (2014) reported that one teacher would share a problem and then receive advice from the others. The author concluded that using a protocol to guide the discussions kept conversations focused on practice and student learning.

According to Hord and Sommers (2008), schools that describe themselves as a professional learning community should exhibit the following characteristics: (1) supportive and shared leadership; (2) shared values and vision; (3) collective learning and the application of learning; (4) supportive conditions; and (5) shared practice. DuFour, DuFour, Eaker, and Many (2006) further described the environment of PLCs as innovative. He explained this as a place where teachers collaboratively develop instructional strategies from student data, try the instructional strategies, and then come back together to reflect. However, PLCs might look different from school to school. This might be due to the make-up of the teaching staff as it relates to years of experience and the nature of their working relationships. For example, Horn and Kane (2015) determined that experienced teachers had more productive PLCs than teachers new to the field. The authors reported that in PLC meetings, veteran mathematics teachers thought more conceptually of the content and focused more on student learning than beginning teachers. In another study, Nickerson and Moriarty (2015) found the relationship between teachers impacted the success of a PLC. In other words, teachers that got along were more likely to work toward school-wide goals.

Regardless of differences in PLCs from school to school, PLCs have been noted as the most effective type of PD (DuFour, Eaker, & DuFour, 2005). That might be why schools in many states incorporate PLCs in their PD plan (Solution Tree, 2020). In fact, some states require schools to incorporate PLCs (Farley-Ripple & Buttram, 2014; NC Board of Education, 2006). However, establishing effective PLCs take time because it requires changing how teachers interact (Roy & Hord, 2006). Therefore, it is likely that PLCs vary due school circumstances.

Coaching. In 2006, then NCTM president Skip Fennell urged schools to provide teachers with the support they need by hiring school-based mathematics specialists [coaches]. Several research studies conducted since 2006 support his claim (e.g., Campbell & Malkus, 2011; Hopkins, Ozimek, & Sweet, 2017). For example, Campbell and Malkus (2011) determined that three years of coaching had a significant impact on student achievement. Stein and Kaufman (2010) investigated the details of coaching activities. They found that coaching was more effective when the coach engaged teachers in conversations around mathematical concepts and student learning. More specifically, the coaches that only supported teachers with material management did not influence a change in instruction. Other research also provides evidence that coaching experiences are likely to vary. Mudzimiri, Burroughs, Luebeck, Sutton, and Yopp (2014) reported on how several coaches spent their day, verifying the variation of activities across coaches. Activities included meeting with teachers to plan instruction, providing a teacher with feedback, creating materials for teachers to use, and showing a teacher how to use learning apps for tablets.

Knight (2009) explained the purpose of coaching is to improve instruction and described different roles of a school-based coach such as data coach, resource provider, mentor, and curriculum and instructional specialist. Similarly, Killion (2012) described different types of coaching. One example is peer coaching or when teachers support one another. This might happen when two teachers plan, observe, and reflect on their instruction together. Cognitive coaching follows a specific protocol for coaching and works on developing teachers to be self-directed learners through guided reflection. For example, a coach may ask a teacher to think about how students could be more engaged during instruction with the presumption that the teacher may start reflecting and recognizing how to improve instruction without being prompted. Other coaching focuses specifically on content. For example, a mathematics coach might engage teachers in planning activities or looking at student assessments. In the same way, West and Staub (2003) described content-focused coaching as a cycle of planning, observing, and reflecting. Although the report of the 2018 National Survey of Science and Mathematics Education (NSSME; Horizon Research, 2018) provides evidence that many US elementary teachers have access to coaching, the type of coaching they experience is unclear.

External PD

Many different experiences are categorized as external PD which is defined as PD that occurs outside of the regular school routine. Some examples include attending conferences and workshops, participating in a district PD, and taking part in a research partnership. In this study, external PD is further sorted into resource-focused PD and mathematics-focused PD. The purpose of resource-focused PD is to train a teacher on using or implementing a school-provided material like a textbook. Mathematics-focused PD is not focused on a resource but instead might emphasize a specific instructional or planning strategy.

Resource-focused PD. There is evidence that teachers attend PD to learn about a school-provided resource. Several studies report teachers attending PD to learn about a new textbook (Collopy, 2003; McGee, Polly, & Wang, 2013; Stickles, 2011). However, the activities that take place during the PD can be very different. For example, some PD might provide minimal opportunities to learn about mathematics. Collopy (2003) described an afternoon training provided to teachers piloting a new textbook, which only incorporated pointing out certain features of the new curriculum. On the other hand, McGee, Polly, and Wang (2013) reported on a state-funded partnership aimed to support districts with the implementation of a new curriculum. Several teachers from each school attended the sessions that started with a summer institute and continued with several meetings throughout the school year. The teachers reported the training to be beneficial and liked learning about student-centered instruction through their engagement in problem-solving tasks. Despite teachers' perspectives on the training's benefits, the authors found teachers skipped lessons that required a lot of preparation and activities that relinquished teacher control. Moreover, the authors discovered that teachers in testing grades went back to teacher-guided instruction to prepare students for end-of-grade assessments. In another example, researchers reported on teachers' participation in PD focused on learning and implementing an assessment tool (Polly, Martin, Wang, Lambert, & Pugalee, 2015). Teachers attended face-to-face summer sessions and then received virtual support throughout the school year. The authors reported that many of the 138 teachers used the materials provided through the program. However, many of the teachers were not using the program as intended because of challenges such as not having enough time to prepare the materials or administer the evaluation. Teachers also expressed difficulty in trying to connect all the school provided resources. Collectively, these articles provide evidence of teachers participating in PD with an aim to learn about school-provided materials, but the experiences vary as indicated by observed outcomes and teachers' perceptions.

Mathematics-focused PD. An abundance of studies can be categorized as mathematics-focused PD. In one example, Gee and Whaley (2016) describe teachers' engagement in a lesson study cycle (this type of lesson study is adapted from a teacher-led research practice in Japan). The group met during the summer to co-plan lessons and then on several occasions throughout the school year to observe, reflect, and modify the lesson. The authors hoped participants would continue in this practice after the study concluded. However, there was no follow-up information reported. In another example, university-based teacher educators partnered with a school district by providing PD aimed to help teachers recognize the coherence of the mathematics Standards (Bailey, 2013). They met several times throughout three years, which included extended summer meetings. Teachers in the study reported that participation in the PD developed their ability to prepare instruction, assessments, and interactive homework.

University partnerships are not limited to face-to-face PD. Sometimes, PD experiences are online. For example, researchers used grant money to create and implement an online PD program aimed to improve elementary teachers' knowledge of content, pedagogy, and student thinking to support instruction for students with disabilities and students that need additional support (Griffin, Dana, Pape, Algina, Bae, Prosser, & League, 2018). Teachers liked the flexibility of the twelve-month online design and the authors determined that the experience influenced the participating teachers' beliefs and practices. However, student outcomes were not significantly different. In another example, an online format supported teachers in rural areas to increase their knowledge of mathematics content and practices (Luebeck, Roscoe, Cobbs, Diemert, & Scott, 2017). The project used trained facilitators to guide teachers through activities and asynchronous discussions. In addition to the positive outcomes, the authors determined that teachers who were assigned a highly responsive facilitator reported a more positive experience than the teachers with a facilitator that responded less often. This could mean that teachers need consistent feedback and guidance. However, it could also mean that some facilitators are more skilled than others (Borko, Koellner, & Jacobs, 2014).

As indicated by the research studies highlighted thus far in this paper and by meta-analyses (Archibald, Coggshall, Croft, & Goe, 2011; Little & Houston, 2003), most reports of research on PD are the results of university-school or university-school district partnerships. Although this pattern confirms that little is known about locally planned and implemented PD, there are a few examples that provide some information about these opportunities. In one case, Althauser (2015) provided information about the planning and implementation of a two-year district PD. The district seemed to have a deficit view of teachers' capabilities considering that participation was mandated after elementary teachers' content knowledge was blamed for the low achievement scores in the middle schools. School teams met four days per year and engaged in activities such as creating a pacing guide and formative assessments. Findings indicated positive effects on third-grade teachers' efficacy and student assessment scores. Contrary to the deficit perspective, another example of district- planned PD seemed to empower teachers. Lewis, Perry, and Hurd (2009) reported on a lesson study PD that was designed by district coaches and offered during the summer. The authors said that teachers developed an understanding of mathematical concepts and student understanding. More importantly, teachers established lesson study groups in their schools during the following school year. While these are just two examples of locally planned PD that were also studied by researchers, an extraordinary amount of fiscal and human resources are invested into locally planned, external PD experiences every year that are not studied.

Collectively, these aforementioned studies point to the fact that teachers participate in PD external to the school day. However, there is likely variation between opportunities (e.g., purpose, time, support), which means details of PD will help understand the opportunities teachers have.

Self-directed PD

Adult learning theory suggests that adults will seek to learn when they need to solve problems (Merriam, 2001). Kennedy (2016) seems to agree when she states that teachers have already figured out solutions to their problems of practice. This means that regardless of what PD opportunities teachers are provided, they will find ways to improve in their role. For that reason, this study assumes teachers seek PD that is not required by the school or self-directed PD. To date, self-directed PD has not been frequently studied, but there are some instances in the literature that highlight self-directed PD. For example, teachers take college courses specifically designed for teachers to learn about teaching elementary mathematics (Haver, Trinter, & Inge, 2017). In one study, Kutaka and others (2016) determined that participating in an elementary mathematics specialist (EMS) program developed teachers' knowledge and beliefs for teaching mathematics that continued to grow after the program was over. Other research shares similar results when investigating the impact courses had on teachers' knowledge and beliefs about mathematics (Campbell & Malkus, 2014). In another example, a teacher reported taking a college algebra class because understanding the mathematical concepts better improved his instruction (Battey & Franke, 2008). There is also evidence that teachers use social media to obtain information about mathematics. Research shows teachers use Twitter to create a professional network to share resources (Forte, Humphreys & Park, 2012; Carpenter & Krutka, 2014). In one study, teachers reported that their interactions on Twitter were more valuable than locally offered PD (Carpenter & Krutka, 2014). Teachers also use sites like Pinterest to find resources and instructional ideas (Schroeder, Curcio & Lundgren, 2019). It is also likely that teachers engage in other activities that support their mathematics instruction, such as reading books, listening to podcasts, and conducting action research.

PD Activities

The National Research Council (NRC, 2001) suggested that mathematics-focused PD should incorporate content, pedagogy, and student learning. This recommendation is also evident in existing research. PD facilitators have focused on developing teachers' mathematical content knowledge while also focusing on instructional strategies and how students learn. For example, teachers' content knowledge increased, and their instruction included more time for student discussion after participating in PD that used video clips recorded in the participants' classrooms to facilitate discussions around student thinking (van Es & Sherin, 2010). The authors also reported that teacher talk during the sessions became more focused on student thinking, and teachers began to see themselves as learners in their classrooms. In another example, authors reported that learning how to use Standards-based resources in their classroom had positive results on teachers' perceptions about mathematics as well as content and pedagogical knowledge (Heck, Banilower, Weiss, & Rosenburg, 2008). The authors conclude that PD that address all three areas are more likely to effect practice.

The current study used the NRC's recommendation along with other research studies to sort the activities teachers engage in during PD opportunities. What to Teach (W) are focused on content activities, How to Teach (H) are focused on pedagogical activities, and Why Teach This Way (Wy) are activities focused on student learning. Although this study is not attempting to evaluate teachers' PD experiences, it is assumed that participating in WHWy simultaneously increases the potential to learn about Standards-aligned instruction (NRC, 2001; van Es & Sherin, 2010; Heck et al., 2008).

What to Teach

Empirical studies show teachers engage in activities focused on planning instruction. For example, Polly (2012) collected data as he provided ongoing coaching support to four teachers. During the study, the author co-planned lessons and provided teachers with instructional resources to use during instruction. Similarly, other studies describe teachers co-planning with researchers (Chval, Pinnow, & Thomas, 2015; Geiger, Muir, & Lamb, 2016), planning with school-based coaches (Campbell & Malkus, 2011), or planning together with other teachers (Bauml, 2014; Althauser 2015). Teachers also revised or rewrote previously taught lessons (Suh & Seshaiyer, 2015; Murata, Bofferding, Pothen, Taylor & Wischnia, 2012). In one example, teachers worked together to create a student task from a textbook problem (Oslund, 2016). Other teachers unpacked lessons from a newly adapted textbook (McGee, Polly, & Wang, 2013). For example, Collopy (2006) described how one teacher read the teacher notes in the textbook to determine how she should implement the lesson. Teachers also planned how resources would be used. For example, teachers discussed which manipulatives and games would best fit into a lesson (Bauml, 2014) while other teachers selected activities or materials to use with students (Borko, Mayfield, Marion, Flexer, & Cumbo, 1997; Hunter & Hall, 2008; Forte, Humphreys & Park, 2012; Stein & Coburn, 2008; Stein, Smith & Hughs, 2008; Baxter, Ruzicka, Beghetto & Livelybrooks, 2014).

How to Teach

Empirical studies show two ways in which teachers engage in activities focused on how to teach. The first is by taking a student perspective. This happens when a facilitator models an instructional strategy by assuming the role of a teacher, and the teacher engages in the lesson as a student. In one example, teachers participating in a yearlong PD on cognitively demanding tasks had the opportunity to engage in lessons at the start of each session (CITE). This allowed the facilitator to model how to implement this type of lesson. While the PD had a significant impact on knowledge and beliefs, observations showed that teachers were just beginning to use the demonstrated practices during their own instruction. This suggests that knowledge and beliefs change before instruction changes. Perhaps teachers are reluctant in trying new methods because these experiences bring awareness to a lack of conceptual understanding. For example, teachers' confidence in their ability to solve mathematics problems decreased after participating in PD that included experiencing a lesson from a student perspective (Zwiep & Benken, 2013). Specifically, in one session, teachers worked together on a student task that examined the slope of a ramp while the facilitators modeled a collaborative learning environment that valued the process of problem solving. According to the authors, the experiences confronted teachers' understanding of mathematics which resulted in decreased confidence. Other researchers have found that teachers' already held beliefs about mathematics influences their participation during PD. For example, Battey and Franke (2008) described a teacher participating in PD who believed mathematics is a collection of steps and formulas. She tended to solve tasks by using the exact methods she saw other participating teachers use during the PD sessions. She could not explain or generalize, but she was very proud at how quickly she finished. In comparison, another teacher who lacked confidence solved the tasks without engaging with others in the group. Later, this participating teacher admitted that he did not want his co-workers to know that he did have a good understanding of mathematics. This provides evidence that a safe supportive environment promotes learning. Although these studies report different types of outcomes, collectively they provide evidence that engaging in a lesson as a student provides teachers with opportunities to learn about content and pedagogy.

The second way in which teachers engage in activities focused on teaching is by observing and practicing instructional strategies. One such example of this type of PD is participation in lesson study. PD focused on lesson study provides teachers multiple opportunities to watch instruction and time to practice new teaching methods (Fernandez, 2005; Suh & Seshaiyer, 2014). In one example, observations led teachers to pay more attention to student learning when it was their turn to teach (Murata, Bofferding, Pothen, Taylor, & Wischnia, 2012). Manipulatives were the focus of a different lesson study, which allowed teachers to practice explaining fractional models (Lewis & Perry, 2017). Another example of PD focused on observing and practicing instructional strategies is video-focused PD that highlights a specific instructional strategy. These PD experiences might include the use of video to highlight how questioning can be used to engage students in a lesson (Santagata, Kersting, Givvin & Stigler, 2011) or opportunities between PD sessions to practice new strategies learned (Clark et al., 2013). These experiences are important because teachers are sometimes uncertain about what instruction should look like and question if they are doing it correctly (Stickles, 2011). Moreover, teachers sometimes need these relevant PD experiences of observing and practicing to be convinced that student-centered lessons will prepare students adequately for end-of-grade assessments (McGee, Wang, & Polly, 2013).

Why Teach this Way

To understand the why of teaching, teachers engage in activities focused on how students learn and understand mathematics. The literature shows that some teachers spend time analyzing student work (Garet et al., 2016; Kazemi & Franke, 2004). In one example, the facilitator asked teachers to think about and explain incorrect responses (Santagata, Kersting, Givvin, & Stigler, 2011). Other teachers discussed student thinking after watching videos of classroom instruction (van Es & Sherin, 2010; van Es, 2012). Other activities provided teachers time to make sense of the Standards. For example, teachers participating in a district-led PD developed a curriculum by first examining Standards and then compiling resources that were aligned (Althauser, 2015). In another study, teachers practiced using Standards-aligned formative assessments to plan future instruction (Polly, Martin, Wang, Lambert & Pugalee, 2016). *Why* activities also include reflection prompts when PD facilitators ask participating teachers to reflect on a particular topic. For example, while watching a video of her own instruction, a teacher was asked to reflect on the lack of opportunities a specific group of students had to participate in the lesson (Chval, Pinnow, & Thomas, 2013).

To summarize, the PD in which teachers participate can be described as embedded, external, or self-directed experiences. That is, teachers engage in a variety of activities to develop their understanding of What to Teach, How to Teach, and Why Teach this Way (WHWh). Effectiveness of the PD was not an emphasis in most studies due to inconsistencies between how researchers define and measure effectiveness (Guskey, 2003). However, there is some consensus on design features for effective PD based upon the results of large-scale empirical studies that had positive impacts on instruction and student outcomes (Darling-Hammond et al., 2009; Garet et al., 2001). Darling-Hammond and colleagues (2017) further developed these ideas in a 2017 report titled *Effective Teacher Professional Development* that explain seven common design features. There are connections between the seven features and the PD types and activities described above. For example, embedded coaching connects to the design feature of “coaching and expert support”. See Table 4.1 for other connections.

Table 4.1
Connections Between the TLO-M and Features of Effective PD

Features of Effective Professional Development as defined by Darling-Hammond and colleagues (2017) in the report titled *Effective Teacher Professional Development*.	**TLO-M PD Types and Activities**
Is ***content focused***.	WHWy activities are supported with empirical evidence showing teachers are provided PD opportunities to learn about the mathematics they are expected to teach.
Incorporates ***active learning*** utilizing adult learning theory.	WHWy activities are supported with empirical evidence showing teachers are actively engaged in PD. Moreover, self-directed PD that shows teachers choose what and how to learn aligns with adult learning theory.
Supports ***collaboration***, typically in job-embedded contexts.	Types of PD and activities are supported with empirical evidence showing teachers collaborate with others during PD.
Uses ***models*** and modeling of effective practice	WHWy activities (How to Teach) are supported with empirical evidence showing models such as observations, video, and curriculum resources are incorporated into PD.
Provides ***coaching and expert support.***	Empirical evidence shows coaching as a type of embedded PD.
Offers opportunities for ***feedback and reflection.***	WHWy activities are supported with empirical evidence showing teachers are provided feedback and reflection opportunities during PD.
Is of sustained ***duration.***	Empirical evidence that PD is embedded into a typical school day as well as external PD offered in multiple sessions over time.

School Context

School context includes circumstances specific to a school such as its location and characteristics of the people in the school community (e.g., teachers, students). Additionally, school context can be described by the expectations set by the school principal (e.g., the amount of time spent on mathematics instruction and which teachers are selected to attend external PD). According to DuFour (2001), the most important role of a principal is to create an environment that fosters embedded learning. Research shows effective leadership positively impacts instruction and student learning (Hitt & Tucker, 2016; Patton, Parker, & Tannehill, 2015;

Robinson, Lloyd, & Rowe, 2008). Additionally, principals' decisions about the school schedule, provided resources, and school-based coaching might influence mathematics teaching and learning.

Schedule. It can be assumed that many factors such as student needs and available staff influence the school schedule. This may explain some of the variation in embedded PD opportunities. For example, Stein and Coburn (2008) reported different ways in which school schedules allowed time for teachers to collaborate. Some schools had designated times for PLCs to discuss mathematics while others did not. One school combined the student lunchtime with teacher planning time, which made attendance to PLC meetings inconsistent. Teachers might also have opportunities to collaborate if they are provided planning periods when they are not responsible for students. Bauml (2014) described how a new teacher used daily planning to work to discuss mathematics instruction with other teachers. Together these studies show decisions about the school's schedule can encourage or hinder learning opportunities.

Resources. School principals make decision around which resources are provided, how much time will be allotted to discuss resources, and the expectations for use (Mitchell & Castle, 2005). Teachers have access to different resources that may influence their mathematics instruction. For example, some teachers might be provided with a Standards-aligned curriculum (Harmon, Gordanier, Henry & George, 2007; Stein & Coburn, 2008; Stickles, 2011). Sometimes, curriculum materials include teacher PD components like assessment guides, student samples, and suggestions on facilitating a student-centered lesson (Superfine, Kelso, & Beal, 2010). For this reason, the instruction may shift, which is why NCTM (2014) recommends providing such resources. However, providing a textbook does not necessarily change teaching because teachers perceive and use the provided resources differently. In fact, research has indicated that teachers often enact lessons differently than Standards-aligned textbooks suggest (Brown; 2009; Sherin & Drake, 2009). Therefore, it seems that providing a resource should be accompanied by opportunities to discuss and understand how the resource can support Standards-based instruction. Although these examples focus on textbooks, it can be assumed that other resources such as manipulatives and games would also require PD.

School-based coaching. For coaching to be effective, coaches need to spend time with the teachers. However, that is not always the case. Neufeld and Roper (2003) found that a principal's beliefs influence how the coach is utilized. This means some coaches carry out non-instructional duties like organizing materials. Other studies report similar findings (Salkind, 2010; Stein & Kaufmann, 2010). On the other hand, principals that are involved in teacher PD tend to delegate responsibilities to coaches that focus on the development of teachers, often making time in the school schedule for the coach and teachers to meet. However, working with a teacher during scheduled times will only be effective if the coach has specialized skills (Gibbons & Cobb, 2016) that include expert content knowledge as well as experience working with adult learners. Principals need to be aware that some new coaches may be uncomfortable providing staff PD or may be unsure how to handle teachers that are resistant to coaching (Chval, 2010). Ellington and Havar (2013) suggested that new coaches can practice by coaching teachers that want to be coached. Regardless, the principal's decisions about the coach's role and responsibilities, just like their decisions about the school schedule and utilization of resources, will impact teachers' learning opportunities related to mathematics teaching and learning.

The implementation of the CCSS-M aimed to better education for all U.S. students. As a result, the expectations of teaching have changed which means teachers need PD to develop the specialized knowledge and skills needed to provide such instruction. Research has provided information about Standards-aligned teaching and examples of PD to support it. However, little is known about the majority of provided PD. For that reason, this study seeks to provide the field with information about teachers' opportunities to participate in mathematics-focused PD. The study, focused on K-5 teachers working in the same district, was guided by the following research questions:

1) From the perspective of elementary school teachers working in the same district, in which mathematics-focused learning opportunities do teachers engage?
2) What is the relationship between mathematics-focused learning opportunities and other factors (e.g., grade level, years of experience, school contextual factors)?

Method

Participants

Data were collected from 174 teachers from 23 elementary schools in the same district located in the southeastern United States. In the district, there were approximately 630 teachers who were eligible to participate because they worked in the district during the 2018/19 school year as a K-5 classroom teacher that provided mathematics instruction. Therefore, the 174 participants represent a 28% response rate. The sample was primarily female (98%), represented each grade level from kindergarten through fifth grade, and had a range of teaching experience. Table 4.2 provides details on these demographics along with information about their age, number of years of experience at their current schools, highest degree completed, and completion of elementary mathematics specialist program.

Table 4.2

Descriptive Characteristics of Teacher Participants

		Number of Teachers
Age (years)	Under 25	4
	25-39	75
	40-59	53
	60 or more	3
Teaching Experience (years)	Less than 5	33
	5-14	62
	More than 15	42
Years Teaching at School	Less than 5	72
	5-14	51
	More than 15	13
Grade	Kindergarten	30
	First	28
	Second	34
	Third	30
	Fourth	27
	Fifth	20
Degree	Bachelor's	105
	Master's	31
Elementary Mathematics License	Yes	8
	In the process	1
	No	128

Note. This table reports data collected from the participants that completed demographic items.

Measure

The Teachers' Learning Opportunities in Mathematics (TLO-M) is a web-based survey in which elementary teachers report on their PD opportunities focused on the mathematics they teach. The survey items connect to research on PD design studies as well as empirical studies of elementary teachers' learning of mathematics. Validity evidence of the instrument was collected through an expert review, three rounds of cognitive interviews, and a pilot study. First, experts guided the creation of definitions and scoring and also confirmed the TLO-M content to be appropriate for the intended purpose of reporting teachers' learning opportunities. Second, data from multiple rounds of cognitive interviews directed changes and confirmed the TLO-M items were understood as intended and matched teachers' experiences. Lastly, the pilot test confirmed that teachers' experiences matched what was found in the literature. That is teachers participate in embedded, external, and self-directed PD and engage in activities from each WHWy category.

The TLO-M items are used to calculate embedded PD frequency and activity scores, external PD frequency and activity scores, a self-directed PD frequency score, and a school context score. The image on the left side of Figure 4.2 is a visual display of the frequency and activity scores while the image on the right shows what is used to create the school context score (SCS). Information about TLO-M items follows. Additional information about the scoring will be explained in the next section.

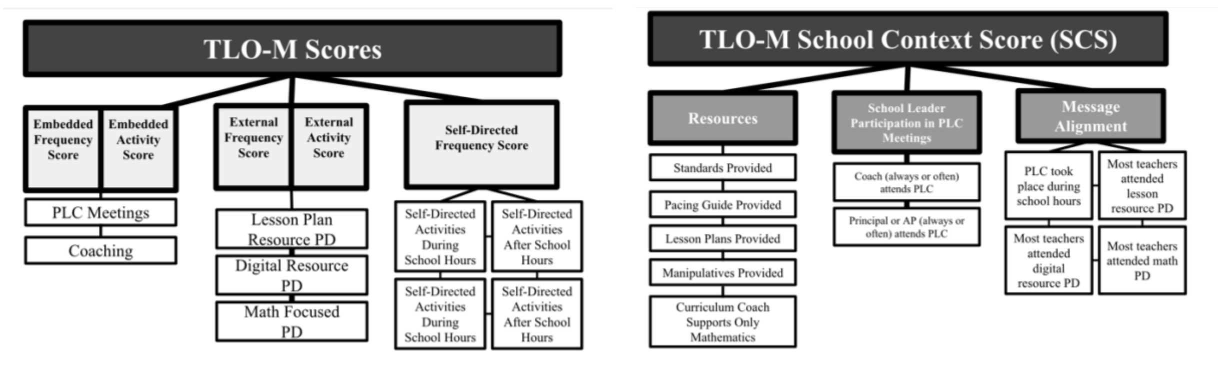


Figure 4.2. Diagram of TLO-M learning and school context scores.

Items Used to Determine Frequency Scores. Using a 0-5 scale, frequency scores are calculated for each type of PD (i.e., embedded, external, self-directed). As shown in Table 4.3, the embedded PD frequency score is the sum of four items that inquire about how often a teacher participates in PLC meetings and coaching opportunities. The external PD frequency score is the sum of three items that inquire about time spent in external PD. This includes resource-focused PD (lesson plan resources and digital resources) as well as PD that is not resource-focused which in this study is referred to as mathematics-focused PD. Self-directed PD frequency is the sum of four frequency items which include how often teachers engage in self-directed activities during and outside of work hours and how often teachers use social media to network or find resources during or outside of work hours. It is important to note, the TLO-M utilizes skip logic so that teachers are only asked question that pertain to their experiences. For example, a teacher that is not provided with a lesson plan resource, will not be asked about lesson resource PD. For this reason, teachers will not have the same number of scores.

Table 4.3
Frequency Score Items

Purpose	Items	Response Options	Points for Score
Determine frequency of embedded PD	1. About how often did you receive individual coaching from a mathematics coach? 2. About how often did you receive team coaching from a mathematics coach? 3. About how often did you participate in grade-level mathematics PLC meetings? 4. About how often did you participate in vertical mathematics PLC meetings?	0=never 1=a few times per year 2= about quarterly 3= about monthly 4=about weekly 5= about daily	0-5 on each item
Determine frequency of external PD	1. About how often did you attend lesson plan resource professional development? 2. About how often did you attend digital resource professional development? 3. About how often did you attend mathematics professional development?	0= none 1= up to 3 hours 2= 3-8 hours 3=9-12 hours 4=13-19 hours 5=20 or more hours	0-5 on each item
Determine frequency of self-directed PD*	1. About how often did you engage in self-directed learning activities during the school day to support your 2018/19 mathematics instruction? 2. About how often did you engage in self-directed learning activities after work hours to support your 2018/19 mathematics instruction? 3. About how often did you access social media during the school day to support your 2018/19 mathematics instruction? 4. About how often did you access social media after work hours to support your 2018/19 mathematics instruction?	0=never 1=a few times per year 2= about quarterly 3= about monthly 4=about weekly 5= about daily	0-5 on each item

Note. *Self-directed items included a list of examples (e.g., reading a book, listening to a podcast, attending a mathematics conference).

Items Used to Determine Activity Scores. Five categories are used to determine participation in WHWy activities (See Table 4.4). The TLO-M determines the number of categories included in different PD experiences. For example, a teacher might participate in activities from four of the WHWy categories during PLC meetings and activities from two of the WHWy categories during coaching.

Table 4.4
WHWy Categories and Descriptions

Category	Description
What to Teach	These are planning activities focus on content to teach.
How to Teach (Student Perspective)	These activities focus on demonstrating instructional methods. In these situations, teachers take the role of students and are engaged in activities by a facilitator that takes the role of a teacher.
How to Teach (Observation and Practice)	These activities focus on instructional methods. In these situations, teachers observe someone else teaching mathematics or practice using a new teaching strategy.
Why Teach This Way (Student Learning)	These activities focus on student learning and include things like analyzing student work and then determining the instructional approaches to meet student needs.
Why Teach This Way (Reflection)	These activities are prompted reflections that encourage teachers to think about teaching and learning mathematics.

The set of activity items are repeated up to five times throughout the survey. Specifically, items are displayed if a teacher indicates participating in: (1) collaborative PLC meetings, (2) collaborative coaching opportunities, (3) collaborative lesson plan resource PD (4) collaborative digital resource PD, and (5) collaborative mathematics-focused PD. This means the activity items are not displayed if the teacher indicates a lecture style PD. Figure 4.3 shows the five WHWy categories and the corresponding TLO-M items. Notice that the *How to Teach (student perspective)* item acts as a filter question. This format is used so teachers are only asked questions that are relevant to their experiences. Activity points range from 0-5. As shown in Figure 4.3, bolded italicized font is used to indicate the response that determines if the participant earns a point for the *How to Teach (student perspective)* category. Points for the other categories are determined by answering yes to any question in a given category.

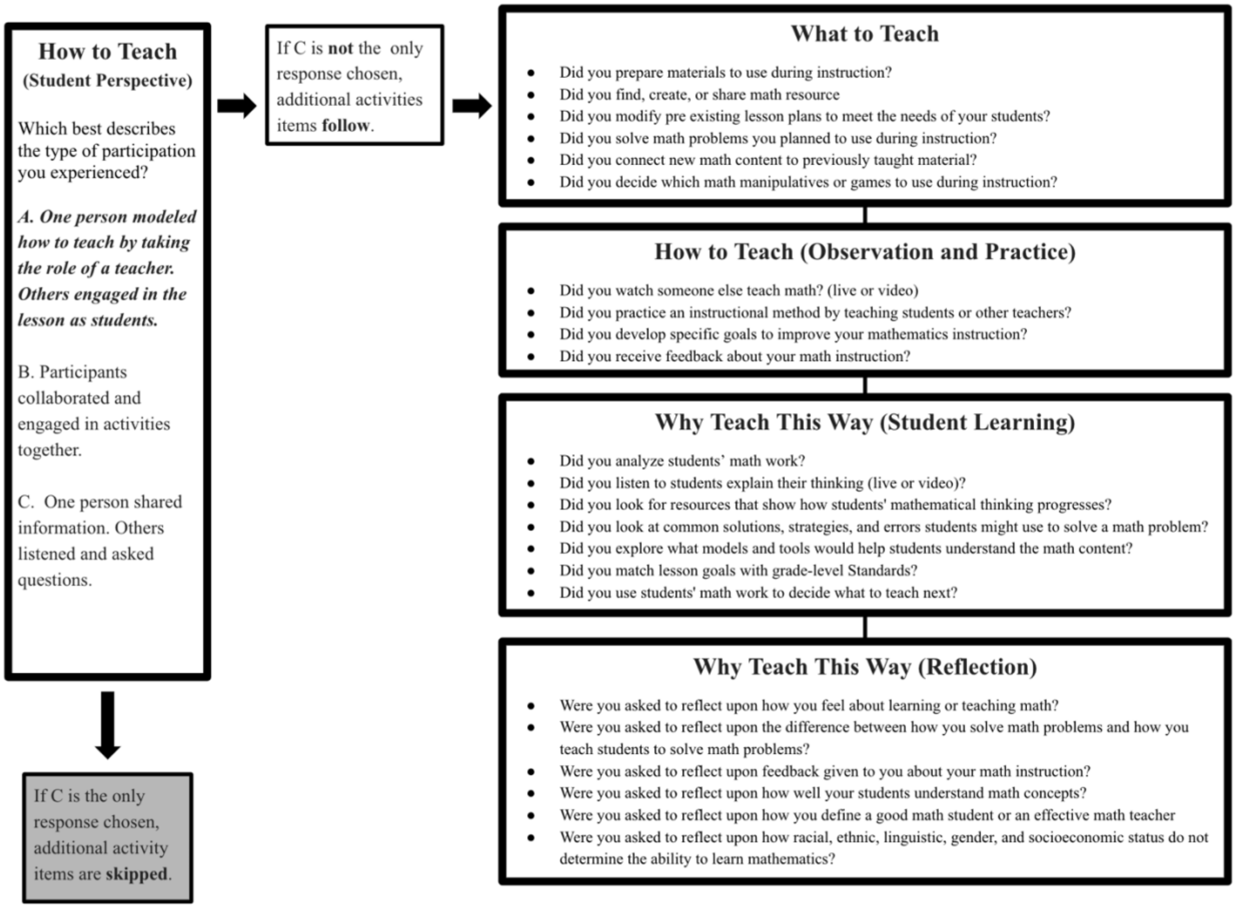


Figure 4.3. WHWy item flowchart.

Items Used to Determine School Context Score. Table 4.5 shows the multiple-choice school context items. Notice there are three focus areas (1) resources, (2) school leader participation in PLC meetings, and (3) message alignment. Resource items ask about school provided resource (Standards, pacing guide, lesson plans, and manipulatives) and if the instructional coach focuses only on mathematics. This study assumes providing resources and a mathematics coach supports teacher learning. School leader participation items ask about the frequency principals and coaches attend PLC meetings. This study assumes school leaders attending PLC meetings sends a message that mathematics instruction is valued. Message alignment items inquire about the time of day PLC meetings occur and the number of teachers that attend PD. This study assumes: more teachers will attend PLC meetings that occur during the school day; and new ideas from PD attended by most teachers at a school will more likely be transferred into practice.

Table 4.5
School Context Items

Purpose	Items	Response Options
Determine Resources	How were you provided access to the mathematics Standards during the 2018/19 school year? (choose all that apply)	• **My school provided me with this resource.** ○ I was provided time during the workday to create or find this resource. ○ I was not provided this resource or time during the school day to find or create this resource.
	How were you provided access to a mathematics pacing guide during the 2018/19 school year? (choose all that apply)	• **My school provided me with this resource.** ○ I was provided time during the workday to create or find this resource. ○ I was not provided this resource or time during the school day to find or create this resource.
	How were you provided access to mathematics lesson plans during the 2018/19 school year? (choose all that apply)	• **My school provided me with this resource.** ○ I was provided time during the workday to create or find this resource. ○ I was not provided this resource or time during the school day to find or create this resource.
	How were you provided access to mathematics manipulatives during the 2018/19 school year? (choose all that apply)	• **My school provided me with this resource.** ○ I was provided time during the workday to create or find this resource. ○ I was not provided this resource or time during the school day to find or create this resource.
	Did the coach provide support for other subjects (e.g. English Language Arts, Science, Technology)?	○ Yes • **No**

Table 4.5 (continued).

Determine School Leader Participation in PLC Meetings	Which best describes how often a mathematics coach participated in PLC meetings?	• **Always** • **Frequently** ○ Sometimes ○ Seldom ○ Never
	Which best describes how often school leaders (e.g., principals, assistant principals) participated in PLC meetings?	• **Always** • **Frequently** ○ Sometimes ○ Seldom ○ Never
Determine message alignment	Which best describes the time of day PLC meetings normally took place?	• **During your scheduled work hours (e.g., between 7:45 am and 3:30 pm)** ○ Before or after your scheduled day ○ A combination of both
	Which best describes the teachers that participated in the 2018/19 lesson plan resource PD?	• **Most of the teachers in my school participated.** ○ A select group of teachers from my school (e.g., first-year teachers, grade-level chairs) participated. ○ I was the only teacher from my school that participated.
	Which best describes the teachers that participated in the 2018/19 digital resource PD?	• **Most of the teachers in my school participated.** ○ A select group of teachers from my school (e.g., first-year teachers, grade-level chairs) participated. ○ I was the only teacher from my school that participated.
	Which best describes the teachers that participated in the 2018/19 digital resource PD?	• **Most of the teachers in my school participated.** ○ A select group of teachers from my school (e.g., first-year teachers, grade-level chairs) participated. ○ I was the only teacher from my school that participated.

Note. The school context score can range from 0-12 with one point given for each of the bolded items in the response option column.

The TLO-M also includes additional items. Some of the items inquire about school organization, such as departmentalization and length of typical mathematics class. Other additional items ask about teacher characteristics such as years of experience, years at the school, and highest degree earned. The TLO-M also includes three optional open-ended questions where teachers can provide additional information about their experiences. Note the open-ended items are not used for this study.

Procedure

The survey was administered near the beginning of the 2019-2020 academic year in a public-school district that agreed to endorse the study. Teachers were invited to participate in the study through an email that also included a link to the TLO-M. Although the district provided the researcher with email addresses for elementary teachers, it appeared that the list included all teachers at the elementary schools regardless of the subjects they teach. Therefore, filter items were used to collect responses from only teachers that met the following criteria: (1) was employed by the district during the 2018/19 school year; (2) taught mathematics to K-5; and (3) was not a special education teacher. As an incentive to complete the survey, which took about 10-20 minutes, participants were eligible to enter a drawing for one of thirty-five $15 gift cards. The link remained active for seventeen days with reminders being sent on day two, seven, and sixteen. School principals were sent emails to encourage participation two times during data collection.

Scoring

As mentioned previously, the TLO-M items are used to quantify teacher learning by frequency, activities, and school context (See Table 4.6).

Table 4.6
TLO-M Scores

TLO-M Scores	Description	Range
Embedded Frequency Score (EMF)	The sum of PLC and coaching frequencies.	0-20
Embedded Activity Score (EMA)	The sum of PLC and coaching activity points.	0-10

Table 4.6 (continued).

External Frequency Score (EXF)	The sum of lesson plan resource PD, digital resource PD, and mathematics-focused PD frequencies.	0-15
External Activity Score (EXA)	The sum of lesson plan resource PD, digital resource PD, and mathematics-focused PD activity points.	0-15
Self-Directed Frequency Score (SDF)	The sum of the self-directed and social media networking frequencies.	0-20
School Context Score (SCS)	Total of 12 Possible Points (one point for each of the following): • Provided lesson plan resource • Provided Standards • Provided manipulatives • Provided pacing guide • Provided daily planning • School leaders (always or often) attending PLC • Mathematics coach (always or often) attending PLC • Curriculum coach focus on mathematics only • PLC occurs during work hours • Most teachers attend LRPD • Most teachers attend DRPD • Most teachers attend MFPD	0-12

Embedded scores. As mentioned previously, the embedded frequency score (EMF) is the combined value of the four PLC and coaching frequency items. EMF ranges from 0-20. Zero indicates no opportunities to participate in PLC or coaching and 20 indicates daily participation in team and individual coaching as well as grade-level and vertical PLC meetings. The embedded activity score (EMA) is the combined value of the PLC and coaching activity points. EMA ranges from 0-10. A score of zero indicates PLC and coaching that does not include any WHWy activities, and a score of ten indicates PLC and coaching with activities from all five WHWy categories. Table 4.7 exemplifies EMF and EMA by explaining the experience of a fictitious teacher named Beth.

Table 4.7
Example of EMF and EMA

EMF

Beth's EMF Score = Grade-Level PLC Frequency (0-5) + Vertical PLC Frequency (0-5) + Individual Coaching Frequency (0-5) + Team Coaching Frequency (0-5)
8 = 4 + 2 + 2 + 0

Beth attended grade-level PLCs weekly (4 points) and vertical PLCs quarterly (2 points). Beth works through a coaching cycle with the school-based mathematics coach. This includes three meeting times per year (2 points). Therefore, Beth's EMF score is 8.

EMA

Beth's EMA Score = PLC Activity Points (0-5) + Coaching Activity Points (0-5)
8 = 4 + 4

During weekly grade-level PLC meetings, Beth worked with other teachers to determine how the textbook lesson might be modified to meet the needs of the students in their classes (1 point for What to Teach). This included anticipating how students will solve and planning questions to prompt student thinking (1 point for Why Teach this Way (student learning)). They also agreed upon common formative assessments that provided information about student learning and then reflected upon the data after the assessment was given (1 point for Why Teach this Way (reflection)). During vertical PLCs, the school mathematics coach modeled instructional strategies by facilitating a problem-solving lesson (1 point for How to Teach (student perspective)). After the lesson, teachers discussed how students at various grade levels might think about the same problem. In this case, Beth participated in 4 of the possible 5 activities during PLC meetings. Therefore, Beth has 4 PLC activity points.

During the coaching cycle, Beth and the school-based coach planned a lesson (1 point for What to Teach). Beth chose a three-lesson format because she wanted to create more opportunities for students to problem solve (1 point for How to Teach). The coach observed Beth's lesson and then they met to reflect (1 point for Why Teach This Way (reflection)). During that time, the two also discussed student work generated during the lesson and thought about further instruction (1 point Why Teach This Way (student learning)). In this case, Beth participated in 4 of the possible 5 activities during coaching meetings. Therefore, Beth has 4 coaching activity points.

External scores. The external frequency score (EXF) is calculated from the combination of three external PD frequency items. EXF ranges from 0-15. A zero score indicates the absence of external PD and a score of 15 indicates twenty or more hours of participation in lesson resource PD, digital resource PD, and mathematics-focused PD. The external activity score (EXA) is the combined value of the external PD activity points. EXA ranges from 0-15. A zero score indicates external PD with no WHWy activities and a score of 15 indicates three external experiences that each included activities from all five WHWy categories. Table 4.8 exemplifies EXF and EXA by explaining the experience of a fictitious teacher named Beth.

Table 4.8
Example of EXF and EXA

EXF

Beth's EXF Score = Lesson Resource PD Frequency (0-5) + Digital Resource Frequency (0-5) + Math-Focused PD Frequency (0-5)
5 = 5 + 0 + 0

Beth attended district training sessions that focused on the adopted curriculum. The group met for a week in the summer (40 hours) and then four times throughout the school year (32 hours). Therefore, Beth's Lesson Resource PD frequency is 5 (20 or more hours). Beth did not attend any other external PD.

EXA

Beth's EXA Score = Lesson Resource PD Activity Points (0-5) + Digital Resource PD Activity Points (0-5) + Math-Focused PD Activity Points (0-5)
4 = 4 + 0 + 0

During the summer sessions, a mathematics specialist engaged the teacher in model lessons (1 point for How to Teach (student perspective)). The teachers worked together to determine how students might respond on the provided assessments (1 point for Why Teach this Way (student learning)). Teachers also watched videos to see how instruction might look in classroom (1 point for How to Teach (observation/practice)). During the school year sessions, teachers observed each other facilitating a number talk with their students.* Then teachers reflected on the different student responses (1 point for reflection). In this case, Beth participated in 4 of the possible 5 activities during PD. Therefore, Beth's external PD activity points total 4.

*no points are indicated because this is a second example of observation, so the observation point was already noted

Self-directed score. The self-directed frequency score (SDF) is the sum of four self-directed frequency items. The SDF range from 0-20. Table 4.9 provides an example using a fictitious teacher named Beth. The highest possible SDF is 20 and would indicate a teacher that participated in daily self-directed learning and social media networking both during and outside of work hours.

Table 4.9
Example of SDF

Beth's Self-Directed Score = Frequency of SD Activities During Work Hours + Frequency of SD Activities Outside of Work Hours + Frequency of Social Media Networking During Work Hours + Frequency of Social Media Networking Outside of Work Hours

10 = 4 + 1 + 0 +5

Self-Directed Activities: Beth listens to a podcast hosted by two mathematics teachers during her Wednesday planning period (4 points for weekly during work hours frequency). She also attends the yearly state mathematics conference with her former college roommate who teaches in a different district (1 point for once-per-year outside of work hour frequency).

Social Media Use: Beth never has time to use social media during the school day (0 points for social media use during work hours). However, Beth networks daily with other mathematics teachers in a closed Facebook group outside of work hours (5 points for daily social media use outside of work hours).

School context score. The school context score (SCS) is calculated from the school context items. The SCS can range from 0-12 with one point given for each of the following: (1) school provides a lesson plan resource, (2) school provides Standards, (3) school provides manipulatives, (4) school provides a pacing guide, (5) teacher is provided with daily planning, (6) school leaders (always or often) attend PLC, (7) coaches (always or often) attend PLC, (8) curriculum coach focuses on mathematics only, (9) PLC occurs during normal work hours, (10) most teachers attend lesson resource PD, (11) most teachers attend digital resource PD, and (12) most teachers attend mathematics-focused PD. Notice on Table 4.5, the bolded response choices indicate how the point is determined.

Analysis

Descriptive statistics and frequencies were used to compute TLO-M scores to address the first research question: From the perspective of elementary school teachers working in the same district, in which mathematics-focused learning opportunities do teachers engage? As described earlier, data was collected from 174 eligible participants; however, scores were only calculated for the items completed. For example, if a teacher stopped taking the survey before answering self-directed items, the teacher will not have a self-directed frequency score. The survey data was first examined for quality (e.g., check to make sure data was in expected range, look for missing data) and inspected for errors (e.g., summary statistics, visualizations). Then, the data was manipulated to create new variables needed to calculate scores (e.g., activity points, combined frequencies). Finally, scores were calculated, and descriptive statistics were examined.

Stepwise linear regression models were conducted separately for five scores (EMF, EMA, EXF, EXA, SDF) to answer the second research question: What is the relationship between mathematics-focused learning opportunities and other factors (e.g., grade level, years of experience, school contextual factors)? Five variables were considered as independent variables for regression models for each of the TLO-M scores. The variables used were school context score (SCS), departmentalization (MORECLASS), less than five years of teaching experience (TEACHLESS5), completion of a master's degree (DEGMD), having or being in the process of obtaining a mathematics specialist license (MSLD), and Title1 status (TITLE1). The purpose of using stepwise linear regression is to determine what combination of variables (if any) has a significant relationship with the dependent variable. The stepwise selection method is a common procedure that adds and removes variables one at a time to create a model with the best predictive ability (Marasinghe & Koehler, 2018). This means, each model only includes the variables considered to be significant. Stepwise will not produce the best model if there are redundant independent variables. To avoid overfitting, independent variables were carefully chosen (Babyak, 2004). For example, grade level was not used as an independent variable because it had a strong correlation with being departmentalized (i.e., whether a teacher taught only mathematics or only mathematics plus another subject).

Regression was determined to be appropriate after verifying the data met regression assumptions (Chen, Ender, Mitchell, von Eyben, & Wells, 2004). Specifically, it was determined that outliers did not significantly change the results of the regression, t-test showed a linear relationship between dependent and independent variables, and a White test showed the residual was homogenous. Moreover, a Chi-Square goodness-of-fit test determined the sample had a similar percent of teachers with a master’s degree and elementary mathematics specialist (EMS) license. An EMS earns credentials to be specialized in teaching mathematics. It is important to note that 22% of the teachers in the sample had a master’s degree, which is less than the reported state percent (33%) of elementary teachers with a master’s degree (NCTS, 2011). However, in

2013 the state stopped compensating teachers with a master's degree, so it is possible the percent of teachers with a master's degree decreased. Therefore, the decision was made to keep master's degree in the model. Likewise, EMS was kept in the model because the 6% of EMS participants in this study was similar to the 4% of EMS teachers determined to be working in medium-size school districts in another study (Markworth, Brobst, Ohana, & Parker, 2016). Correlations between variables are shown in Table 4.10.

Table 4.10
Correlations Between Variables (Pearson's correlation, r)

		1	2	3	4	5	6	7	8	9	10	11
1.	Embedded Frequency Score	1.00										
2.	External Frequency Score	0.04	1.00									
3.	Self-Directed Frequency Score	0.32***	0.05	1.00								
4.	Embedded Activity Score	0.29***	0.12	0.04	1.00							
5.	External Activity Score	0.06	0.57***	0.08	0.19	1.00						
6.	School Context Score	0.47***	0.18	0.05	0.19*	0.02	1.00					
7.	Departmentalized	0.20*	0.04	0.12	0.18*	0.22*	0.03	1.00				
8.	Title1 Status	0.13	0.08	0.01	0.11	0.08	0.11	0.08	1.00			
9.	Master's Degree	0.12	0.04	0.19*	0.12	0.04	0.26**	0.01	0.14	1.00		
10.	Elementary Mathematics Specialist	0.18*	0.09	0.12	0.02	0.14	0.05	0.11	0.12	0.00	1.00	
11.	Less than five years of teaching experience	0.25**	0.05	0.03	0.09	0.07	0.24**	0.09	0.16	0.10	0.06	1.00

Note. * p<.05; ** p<.01; *** p<.001

Results

The TLO-M scores provide information about the frequencies and activities that teachers reported. Table 4.11 presents the descriptive statistics for all of the TLO-M scores. Notice the bolded text indicates the scores and the grey text indicates items used to create the scores.

Table 4.11
TLO-M Participants' Scores

	N	Mean	STD	MIN	MAX
Embedded Frequency Score	159	6.49	3.95	0	19
PLC Frequency	159	4.50	2.04	0	10
Coaching Frequency	148	2.06	2.75	0	10
Embedded Activity Score	154	2.45	2.16	0	9
PLC Activity	154	2.18	1.75	0	5
Coaching Activity	67	0.64	1.52	0	5
External Frequency Score	79	3.97	2.72	1	10
Lesson Plan Resource PD Frequency	37	3.16	1.59	1	5
Digital Resource PD Frequency	33	1.76	1.28	1	5
Math-Focused PD Frequency	50	2.78	1.52	1	5
External Activity Score	79	2.94	3.06	0	11
Lesson Resource PD Activity	37	2.40	2.14	0	5
Digital Resource PD Activity	33	0.88	1.52	0	5
Math-Focused PD Activity	50	2.28	2.03	0	5
Self-Directed Frequency Score	139	7.32	5.35	0	20
Self-Directed During Work Frequency	139	2.86	2.90	0	10
Self-Directed Outside of Work Frequency	139	4.46	3.02	0	10
School Context Score	156	5.42	1.85	1	11

Embedded PD

Many teachers participated in embedded PD (n=159). The embedded frequency scores ranged from 0-19 (M=6.49, SD=3.95). The scores indicate that some teachers participate in embedded PD more frequently than other teachers. The differences might be due to the variation in coaching and vertical PLC participation. This means that only some teachers engaged with a coach or participated in vertical PLC meetings.

The embedded activity score ranged from 0-9 (M=2.45, SD=2.16). The scores indicate that teachers engage in some WHWy activities during embedded PD. However, some teachers never participated in WHWy activities during embedded PD (See Table 4.12). This could mean that some PLC meetings and coaching opportunities do not include activities that focused on content, pedagogy, or student thinking. Details about PLC and coaching experiences (items used to determine embedded scores) follows.

Table 4.12
WHWy Activity Points (Embedded)

	Five WHWy Activities	Four WHWy Activities	Three WHWy Activities	Two WHWy Activities	One WHWy Activities	Zero WHWy Activities
PLC Activity Points (n=153)	2	53	26	12	3	57
Coaching Activity Points (n=59)	3	6	1	0	1	56

PLC frequency. In this study, 159 teachers answered the PLC frequency items. PLC frequency scores ranged from 0-10 (M=4.50, SD=2.04). As shown in Table 4.13, the majority of teachers (n=149) reported participating in grade-level PLC meetings that focused on mathematics. The frequency of participation varied with most teachers (n=106) meeting daily or weekly, other teachers (n=25) meeting about monthly, and fewer teachers (n=18) meeting up to four times per year. About half the teachers (n=75) also reported participating in vertical PLC meetings. The frequency of vertical meetings occurred less than grade-level PLCs (i.e., n = 15 for daily or weekly; n=26 for one time per year). This shows variation between how often teachers have to discuss mathematics in a PLC.

Data collected also showed most PLC meetings occur during the school day (n=142) and that school leaders (e.g., principals and assistant principals) (n= 98) and coaches (n=52) frequently or always attended the meetings. Equally important, some school leaders and coaches did not regularly attend PLC meetings. This could mean that mathematics instruction is valued more by some school leaders than others.

Table 4.13
Frequency of Reported PLC and Coaching Opportunities

	Daily (at least three times per week)	**Weekly** (about four times per month)	**Monthly** (about eight times per year)	**Quarterly** (about four times per year)	**Yearly** (one or two times per year)	**Never**
Grade-Level PLC (n=159)	7	99	25	17	1	10
Vertical PLC (n=159)	2	13	19	15	26	84
Individual Coaching (n=148)	5	9	8	12	22	92
Team Coaching (n=148)	4	14	13	21	17	79

PLC activities. In this study, 153 teachers answered items about PLC activities. As shown in Table 4.14, many teachers (n=96) reported participating in at least one WHWy activity with some teachers (n=53) engaging in four WHWy activities during PLC meetings. Table 4.14 shows the focus of WHWy activities that were reported. It was common for teachers (n=92) to engage in What to Teach and Why Teach This Way (student learning) activities and less common for teachers (n=7) to engage in How to Teach (student perspective) experience. This suggests that PLCs focus on student data and planning instruction.

Table 4.14
Frequency of Reported WHWy Activities During Embedded PD

	What to Teach		**How to Teach** student perspective		**How to Teach** observation & practice		**Why Teach this Way** student learning		**Why Teach this Way** reflection	
	yes	no	yes	no	yes	no	yes	no	yes	no
Reported PLC Activities (n=96)	92	4	7	89	72	24	92	4	71	25
Reported Coaching Activities (n=11)	10	1	5	6	10	1	10	1	8	3

Coaching frequency. In this study, more teachers (n=123) indicated that their school had a curriculum coach than teachers (n=47) that indicated no school-based coach. Coaching frequency items were completed by 148 teachers (See Table 4.13). The scores ranged from 0-10 (M=2.06, SD=2.75). Fifty-six teachers reported participating in individual coaching. The frequency of individual coaching varied with some teachers (n=14) meeting daily or weekly, some teachers (n=8) meeting about monthly, and other teachers (n=34) meeting up to four times per year. More teachers (n=69) reported participating in team coaching (i.e., n = 56 for individual coaching; n=69 for team coaching). The frequency of team coaching varied with some teachers (n=18) meeting daily or weekly, some teachers (n=13) meeting about monthly, and many teachers (n=38) meeting up to four times per year. This finding suggests that school-based coaches do not work with all the teachers in the school. Perhaps coaching is only provided for teachers that are perceived to need help or maybe the coach does not focus on mathematics.

Coaching activities. Although 123 teachers reported access to a coach, only the 67 teachers that indicated interacting with a coach on the coaching frequency items were asked more about their coaching experiences. Of these 67 teachers, most (n=56) were not asked the WHWy items because they indicated that interactions with a coach were informal and unplanned (See Table 4.15). Therefore, the data reported is from a small sample of 11 teachers that worked collaboratively with a coach and answered all the WHWy items. Findings show it was common for these 11 teachers to participate in a variety of activities during their coaching opportunities (See Table 4.14). It is not clear why few teachers engaged in collaborative coaching activities. Perhaps some coaches have non-coaching duties (i.e., teaching students, organizing testing), or coaching support is not offered for mathematics.

Table 4.15
Formal and Informal Coaching Interactions

Type of Coaching Interactions	Number of Teachers (n=67)
Formal Interactions Met with Coach during Scheduled Meeting Time a Schedule	11
Informal Interactions Interacted with coach to get resource	56

External PD

Due to the utilization of skip logic, not all teachers were asked lesson resource PD items or digital resources PD items. Teachers were only asked about these experiences if they indicated the school provided the resource. On the other hand, all teachers were asked about mathematics-focused PD. The results show that many teachers participated in external PD (n=79). The external frequency scores ranged from 0-9 (M=3.97, SD=2.72). This suggests that teachers have different opportunities. Moreover, much of the PD does not occur for the suggested duration of twenty or more hours (Desimone, 2009). In addition, teachers report attending PD with all, some, or no other teachers from the same school. This variation might influence how new information from the PD informs teachers' practice. First, having the entire staff attend PD together makes the information seem important. Second, attending PD with others will allow further discussion of the ideas presented. The finding did not indicate how teachers were chosen to attend external PD. For instance, it was not more common for new teachers or a certain grade level of teachers to attend. Further information about duration and attendance is included for each external opportunity in the paragraphs that follow.

The external activity score ranged from 0-11 (M=2.94, SD=3.06). The scores indicate that teachers engage in some WHWy activities during external PD. However, some teachers never participate in WHWy activities during external PD (See Table 4.16. Coupled with the duration results, this could mean much external PD is not supporting instructional shifts.

Table 4.16
WHWy Activity Points (External PD)

	Five WHWy Activities	Four WHWy Activities	Three WHWy Activities	Two WHWy Activities	One WHWy Activities	Zero WHWy Activities
Lesson Plan Resource PD (n=37)	9	9	0	1	6	12
Digital Resource PD (n=33)	2	2	1	0	9	19
Math-Focused PD (n=47)	8	15	1	1	9	13

Lesson resource PD frequency. Although 78 teachers reported that the school provided a lesson plan resource, only 37 teachers attended lesson resource PD. Lesson resource PD frequency scores ranged from 1-5 (M=3.16, SD=1.59). As shown in Table 4.17, the frequency of participation varied with some teachers (n=12) attending for 20 or more hours, some teachers (n=18) attending between two and nineteen hours, and other teachers (n=7) attending for less than two hours. This means that only twelve teachers attended lesson resource PD for suggested duration (Desimone, 2017). However, the TLO-M asked specifically about 2018/19 PD, so it is possible that the PD spans multiple years making the contact hours more than adequate.

Nearly all teachers who attended lesson resource PD indicated that the meetings (n=30) took place during regular work hours. Some teachers (n=7) attended the PD with all of the other teachers working at their school, some teachers (n=26) attended with some of the other teachers working at their school, and other teachers (n=3) were the only teacher from their school that attended (one teacher did not indicate who they attended with).

Table 4.17
Frequency of Reported External Opportunities

	5 points 20 or More Hours	**4 points** 13-19 Hours	**3 points** 9-12 Hours	**2 points** 3-8 Hours	**1 point** Up to 2 Hours	**0** Did Not Attend
Lesson Plan Resource PD (n=78)	12	6	2	10	7	41
Digital Resource PD (n=125)	3	1	2	6	21	92
Math-Focused PD (n=143)	11	7	4	16	12	93

Lesson resource PD activities. As shown in Table 4.16, of the 37 teachers who participated in lesson resource PD, more than half the teachers (n=25) reported participating in activities from at least one WHWy category with many teachers (n=18) engaging in activities from four or five WHWy categories. Table 4.18 shows the number of teachers that reported activities in each of the WHWy categories. The difference in their responses could mean that teachers attended different lesson plan resource PD, or perhaps the teachers perceived the same experience differently.

Table 4.18
Frequency of Reported WHWy Activities During External PD

	What to Teach		**How to Teach** student perspective		**How to Teach** observation & practice		**Why Teach this Way** student learning		**Why Teach this Way** reflection	
	yes	no	yes	no	yes	no	yes	no	yes	no
Lesson Plan Resource PD (n=37)	18	19	18	19	17	20	19	18	17	20
Digital Resource PD (n=33)	5	9	11	3	4	10	5	9	5	9
Math-Focused PD (n=47)	25	22	16	31	25	22	25	22	23	24

Digital resource PD frequency. Although 125 teachers reported that the school provided a digital resource, only 33 teachers attended digital resource PD. Digital resource PD frequency scores ranged from 1-5 (M=1.76, SD=1.28). As shown in Table 4.17, the frequency of participation varied with few teachers (n=3) attending for 20 or more hours, other teachers (n=9) attending between two and nineteen hours, and most teachers (n=21) attending for less than two hours. This could mean that for most teachers, the PD was only to introduce the resource. For this reason, it is likely that teachers did not develop skills and knowledge needed to teach mathematics. However, being introduced to a digital resource could change instruction. For example, a teacher attending this PD might incorporate the use of the resource into daily instruction.

Nearly all teachers who attended digital resource PD indicated that the meetings (n=17) took place during regular work hours. Some teachers (n=10) attended the PD with all of the other teachers working at their school, some teachers (n=16) attended with some of the other teachers working at their school, and other teachers (n=1) were the only teacher from their school that attended (six teachers did not indicate who they attended with).

Digital resource PD activities. Almost half of the 33 teachers (n=14) reported participating in activities from at least one WHWy category with some teachers (n=4) engaging in activities from four or five WHWy categories (See Table 4.16). However, more teachers (n=19) reported that the PD did not include any activities focused on WHWy. This suggests that the purpose of digital resource PD is only to introduce the program. As shown in Table 4.18, it was most common for teachers (n=11) to engage in a lesson as a student. This is likely because teachers had the opportunity to log into the program to experience a student lesson.

***Math-focused PD frequency*.** Fifty teachers attended mathematics-focused PD. Math-focused PD frequency scores ranged from 1-5 (M=2.78, SD=1.52). As shown in Table 4.17, the frequency of participation varied with only some teachers (n=11) attending for 20 or more hours.

Nearly all teachers who attended mathematics-focused PD indicated that the meetings (n=40) took place during regular work hours. Some teachers (n=11) attended the PD with all of the other teachers working at their school, most teachers (n=31) attended with some of the other teachers working at their school, and few teachers (n=5) were the only person from their school that attended (three teachers did not indicate who they attended with).

***Math-focused PD activities*.** In this study, 47 teachers answered items about mathematics-focused activities. As shown in Table 4.16, of the 47 teachers, many (n=34) reported participating in activities from at least one WHWy category with some teachers (n=23) engaging in activities from four or five WHWy categories. However, some teachers (n=13) reported that the mathematics-focused PD did not include any WHWy focused activities. This indicates that teachers have different experiences in mathematics-focused PD.

Self-Directed PD

The self-directed frequency score (SDF) is the sum of four frequency items (See Table 4.3) related to the learning activities not required by the school (e.g., listening to a podcast, engaging with other teachers via social media) (M=7.32, SD=5.35). As shown on Table 4.19, the frequency of participation varied with some teachers (n=34) engaging in activities during work hours at least weekly and slightly more teachers (n=39) engaging in activities after work hours at least weekly. In addition, results show that daily or weekly social media was utilized more outside of work hours (n=46) than during work hours (n=21). This could mean that teachers do not have enough time during the school day to engage in learning with their colleagues, or perhaps teachers do not feel comfortable asking their colleagues for help.

Table 4.19
Frequency of Self-Direction PD (n=139)

	Daily (at least three times per week)	**Weekly** (about four times per month)	**Monthly** (about eight times per year)	**Quarterly** (about four times per year)	**Yearly** (one or two times per year)	**Never**
Self-Directed Frequency During Work Hours	16	18	17	17	16	55
Self-Directed Activities After Work Hours	18	21	18	22	22	38
Social Media Use During Work Hours	8	13	9	9	7	93
Social Media Use After Work Hours	19	27	32	12	3	46

School Context

The school context score (SCS) is the sum of twelve factors (one point per factor), as described in the methods section, that could potentially support PD. As shown in Table 4.11, the SCS ranged from 1-11 (M= 5.42, SD=1.85). Table 4.20 displays the percent of respondents who were assigned a point for each of the school context factors. It was common for participants to report that their school provided manipulatives (93% of the respondents) and had PLC meetings during the school day (96% of respondents). It was less common for participants to report that mathematics-focused PD was attended by most teachers at the school (23% of respondents). The least common school context factor was having a coach that focused only on mathematics (13% of respondents). These results show that school context varies. Furthermore, there was no consistency found within schools. For example, some teachers in a school reported the school providing lesson plans, and other teachers in the same school reported that the school did not provide lesson plans. This could mean school level communication needs to approve.

Table 4.20
Number/Percentage of Participants School Context Points

	Number of Respondents	Number of Yes Responses	Percent of Respondents Assigned Point
School Provided Standards	167	119	71%
School Provided Pacing-Guide	165	66	40%
School Provided Lesson Plans	164	89	54%
School Provided Manipulatives	162	150	93%
School Provided Daily Planning Period	161	119	74%
School Leaders Regularly Attended PLC Meetings	150	98	65%
Curriculum Coach Regularly Attended PLC Meetings	150	52	35%
PLC Meetings Occurred During School Hours	150	144	96%
Curriculum Coach Supports Mathematics Only	75	10	13%
Most Teachers at School Attended LRPD	36	7	19%
Most Teachers at School Attended DRPD	27	10	37%
Most Teachers at School Attended MFPD	47	11	23%

Question Two Results

The results of the regression models provide information about the relationships between learning opportunities and school and teacher characteristics. Stepwise regression analysis allowed to identify which combination (if any) of the independent variables predicted the results of the dependent variables. The results show significant relationships between some of the independent variables and the frequency and activity scores. The only exception was the external PD frequency score. In that case, no significant relationships were found between any of the independent variables and the external PD frequency score.

Embedded Frequency Score (EMF). The embedded frequency score had a significant relationship with: (1) SCS; (2) being departmentalized; and (3) having or being in the process of obtaining an elementary mathematics specialist license. Overall, 30% of the variance in EMF can be explained by SCS, being departmentalized, and EMS (R^2= 0.30). At step one, SCS contributed significantly to the model, accounting for about 21% of the variance in embedded frequency scores, $F(1,133) = 35.46$, $p<0.001$. When being departmentalized was added to the model in step two, 27% of the variance in EMF scores could be explained, $F(2,132) = 24.67$, $p<0.001$. In step three, when EMS was added to the model, 30% of the variance was explained $F(3,131) = 19.07$, $p<0.001$. This means when controlling for the other variables, teachers with an EMS license would be expected to have an EMF score that is on average 2.9 points higher than teachers without an EMS license (See Table 4.21). Other variables (master's degree, years of experience, Title1 status) did not enter the equation at 0.05 levels showing that they are weak predictors of EMF.

Table 4.21
Summary of Regression Analysis for Factors Predicting Embedded Frequency Score

Step	1	2	3
Constant	1.24	0.46	0.23
School Context Score	0.96***	0.99***	1.01***
Departmentalized		2.27**	2.10**
EMS			2.90*
R^2	0.21	0.27	0.30
ΔR^2		0.06	0.03

Note. *$p<0.05$;**$p<0.01$;***$p<0.001$.

Embedded Activity Score (EMA). The embedded activity score had significant relationships with: (1) SCS; and (2) being departmentalized. Overall, 8% of the variance in EMA can be explained by SCS and being departmentalized ($R^2= 0.08$). At step one, SCS contributed significantly to the model, accounting for about 4% of the variance in EMA, $F(1,129) = 5.50$, $p<0.05$. When being departmentalized was added to the model in step two, 8% of the variance in EMA scores could be explained, $F(2,128) = 5.74$, $p<0.01$. This means when controlling for the other variables, teachers that are departmentalized would be expected to have an EMA score about one point higher than teachers that are not departmentalized (See Table 4.22). Other variables (master's degree, years of experience, Title1 status, EMS) did not enter the equation at 0.05 levels showing that they are weak predictors of EMA.

Table 4.22
Summary of Regression Analysis for Factors Predicting Embedded Activity Score

Step	1	2
Constant	1.17	0.84
School Context Score	0.23*	0.24*
Departmentalized		0.98*
R^2	0.04	0.08
ΔR^2		0.04

Note. *$p<0.05$;**$p<0.01$;***$p<0.001$.

External Activity Score (EXA). The only independent variable to have a significant relationship with the external activity score was being departmentalized, $F(1,72) = 4.87$, $p<0.05$. Overall, 6% of the variance in EXA scores can be explained by being departmentalized (R^2= 0.06). This means teachers that are departmentalized would be expected to have an EXA score 1.6 points higher than teachers that are not departmentalized (See Table 4.23). This also means the other variables (SCS, master's degree, years of experience, Title1 status, EMS) are not significantly related to EXA.

Table 4.23
Summary of Regression Analysis for Factors Predicting External Activity Score

Step	1
Constant	2.27
Departmentalized	1.60*
R^2	0.06

Note. *$p<0.05$.

Self-Directed Frequency Score (SDF). The only independent variable to have a significant relationship with the self-directed frequency score was having a master's degree, $F(1,133) = 4.87$, $p<0.05$. Overall, 3% of the variance in SDF scores can be explained by having a master's degree (R^2= 0.03). This means teachers with a master's degree would be expected to have an SDF score 2.35 points higher than teachers that do not have a master's degree (See Table 4.24). This also means the other variables (SCS, departmentalized, years of experience, Title1 status, EMS) do not have a statistically significant relationship with SDF.

Table 4.24
Summary of Regression Analysis for Factors Predicting Self-Directed Frequency

Step	1
Constant	6.85
Departmentalized	2.35*
R^2	0.03

Note. *p<0.05.

Discussion

Teachers need PD to develop the knowledge and skills needed to teach Standards-based mathematics (Ball, Thames, & Phelps, 2008; National Research Council, 2001). Little is known about the majority of PD opportunities that are locally provided (Sztajn, 2011). This study investigated the PD experiences of teachers working in one school district. The results indicate that teachers participate in three types of PD (i.e., external, embedded, self-directed) which often include at least one WHWy activity. The frequency and activities teachers reported vary greatly. However, some of the variation can be explained by teacher characteristics and school context.

Embedded PD

The results of this study suggest that embedded opportunities are common with many teachers reporting that they participated in grade-level PLC meetings. The frequency of participation varied with some teachers only meeting four or fewer times per year. This was surprising because meeting four times per year does not seem like it would meet the state requirement for principals to establish and maintain professional learning communities. However, previous research reported that principals could not meet all the demands of maintaining PLCs, and one size fits all expectations are not realistic (Militello, Fusarelli, Alsbury

& Warren, 2013). Therefore, maybe the variance could be explained by principal characteristics such as years of experience or how well they can manage all the requirements. Regardless of the reason, there seems to be inconsistency between the amount of time teachers participate in mathematics-focused PLC meetings.

Like previous research findings, the results of this study also showed differences in the activities teachers engaged in during PLC meetings and coaching opportunities (Stein & Coburn, 2008). Most notably, about a third of the teachers reported participating in PLCs that never include activities focused WHWy. Moreover, most teacher/coach interactions were informal such that teachers would only seek out coach support when questions arise or when a resource was needed. This also means that the majority of teachers do not engage in WHWy activities with a coach. This finding aligns with previous research that reported the variety of tasks instructional coaches perform like providing and finding instructional resources. (Mudzimiri et al., 2014). However, the informal encounters might also mean that ELA coaching takes priority over mathematics coaching. This might be explained by school leaders' priorities since previous research has found the principal plays an important role in shaping the culture around professional learning, including its focus and nature, within a school (Lee & Li, 2015). More information about the district and school expectations of PLCs and instructional coaches would be helpful in understanding this finding.

Some of the variation in embedded PD was explained. First, it was found that teachers with an EMS license have higher frequency scores than teachers without an EMS license. Interestingly, there was no relationship between having an EMS license and embedded activities. This suggest that teachers with an EMS license participate more often in embedded learning opportunities, but it seems they do not engage differently in WHWy activities associated with those opportunities. Maybe teachers with an EMS license are considered to be teacher leaders and are asked to support other PLCs which would explain a higher frequency score. In the same way, this could also explain no difference in activity scores. That is the EMS teacher engages in the same activities with multiple PLCs; therefore, her frequency score would increase while her activity score would remain the same.

Second, SCS was found to have a significant positive relationship with embedded frequency and activities. This means teachers with higher SCS scores reported participating frequently and engaging in more activities focused on WHWy. This could mean that teachers with higher SCS scores work in schools with school leaders that value mathematics instruction since part of the score is determined by the school provided resources and school leaders participation in PLC meetings.

Finally, the results show that departmentalized teachers have higher frequency and activity scores. This could be explained simply by time. In other words, teachers that teach fewer subjects have more time to focus on the subjects that they teach. This finding aligns with previous research that found that elementary teachers that were departmentalized had more time to plan for the subjects they taught (Strohl, Schmertzing, Schmertzing, & Hsiao, 2014). However, it would be interesting to investigate why some schools departmentalize and others do not. It is possible that departmentalized teachers like mathematics more than other teachers which makes them seek out opportunities to learn with their colleagues during the school day (e.g., working with a coach on mathematics instruction).

External PD

The results of this study show teachers participate in external PD. Some PD is focused on resources provided by the school while other PD is not. In both types, most teachers are not attending for the recommended twenty or more hours (Darling-Hammond et al., 2017). The findings show that each type of external PD includes WHWy activities. However, it appears that digital resource PD experiences engage teacher in the least number of WHWy activities. This could mean digital resource PD only occurs as a way to introduce the provided resource, and teachers are told how to use the resource. It could be argued that those experiences should not even be considered PD due to the disconnected and uncollaborative nature. The results also show variation in the activities teachers report occurring during lesson resource PD. This is interesting because the teachers work in the same district which means they likely attend the same training. However, maybe the sessions were facilitated by different people which might explain some of the variation. For example, there was a different facilitator for each grade level therefore teachers engaged differently due to the differences in the person leading the sessions. Previous research has found that teachers' perception of the facilitator is one-way teachers determine if the PD was worthwhile (Linder, Eckhoff, Igo, & Stegelin, 2013).

Although there was no indication of why teachers' external frequency scores varied, departmentalized teachers had higher external activity scores. This finding makes sense because it is plausible that teachers who focus on fewer subjects seek out higher quality, subject-specific PD opportunities than teachers that teach all subjects. Other research has shown being departmentalized gives teachers more time to plan for the subjects they teach (Strohl, Schmertzing, Schmertzing, & Hsiao, 2014). Therefore, it is reasonable to assume departmentalized teachers also have more time to dedicate to PD in the areas in which they teach. There was a not a significant finding between embedded PD and teacher characteristics like years of experience or grade level. Although it is likely that principals decide which teachers attend external PD, the results indicate the selection is likely based on other characteristics, skills, or variables within the school context.

Self-Directed PD

Like previous studies, the results from this study show that teachers engage in self-directed learning that includes networking with other teachers via social networks (Forte, Humphreys & Park, 2012; Carpenter & Krutka, 2014). It was not surprising that engaging in self-directed PD occurred more often outside of work hours than during work hours due to daily tasks of elementary teachers. However, this finding could mean teachers are not provided adequate time during the school day to collaborate with others about mathematics. Or perhaps the teachers do not find the provided resources helpful which causes them to seek supplemental materials.

The results show some of the variation in SDF scores can be explained by the teacher's degree. Specifically, teachers with a master's degree have significantly higher SDF scores. This could be because teachers with a master's degree have developed a habit of being a life-long learner from spending more time in school and regularly seek out learning opportunities on their own. It was surprising that there was not a significant relationship between SCS and SDF scores because it could be assumed that teachers that are not provided resources need to spend more of their own time finding resources. However, the teachers in this study all worked for the same school district, and all indicated some level of school support (i.e., school context scores > 0). Therefore, the results may be different in future research studies for teachers that indicate no school support.

Conclusion

The TLO-M provided details about learning opportunities for teachers in one school district. The results show not all teachers have the same PD experiences. Understanding the circumstances that surround the PD can provide data to support school leaders with decisions around mathematics PD. For example, the data presented here might lead to more conversations and training with school principals about the expectations of PLCs. Likewise, school leaders might consider departmentalizing or modifying the role of the school-based coach. This study also shows that some teachers do not have opportunities to learn about WHWy, which makes the expectations of Standards-based instruction seem less possible. It does not seem reasonable to expect instruction or student outcomes to change without adequate PD. For that reason, there should be more accountability placed on school leaders making PD decisions.

CHAPTER 5: QUALITATIVE RESULTS

Journal

This article is written as a report to be submitted to the *Journal of Mathematics Teacher Education (JMTE).* The maximum length for a research report is 10,000 words (excluding references, tables, and figures). The journal seeks research that contributes knowledge to the field of mathematics teacher education including all stages of professional development.

Abstract

Professional development is needed to prepare teachers to meet the expectations set by the Common Core State Standards for Mathematics (CCSS-M). Some PD opportunities are job embedded and facilitated through PLC meetings and instructional coaching. Using a two-phase sequential mixed-methods design, this study seeks to understand the embedded learning opportunities focused on mathematics content and pedagogy for elementary teachers in one school district. Data from 106 teachers working in ten schools in the same district were collected and analyzed during the first phase. Data was then collected from six school leaders working in two of the schools. Results indicate that school leaders influence embedded PD opportunities.

Introduction

The Common Core State Standards for Mathematics (CCSS-M) set expectations for the content and skills students should master by the end of each grade and the practices in which they should use regularly, but these standards do not include directions on how to teach to meet the expectations. The Mathematical Practices for students (e.g., model with mathematics), in particular, have implied that instruction should move from teacher-directed to student-centered instruction. To successfully provide this type of instruction, teachers need to have a deep understanding of both the content and how students understand and learn the material (Ball, 2003; Clements & Sarama, 2004; Carpenter, Fennema, Peterson, Chiang & Loef, 1989). Ball and Forzani (2009) argued that, “most adults do not naturally develop the ability to perform the tasks required of teachers. And, the special knowledge, skills, and orientations that underlie and enable the work of teaching are not typically mere by-products of intelligence or academic talent or success” (p. 500). Therefore, like any highly skilled professionals, teachers will need quality training to develop this specialized knowledge (Ball, Thames, & Phelps, 2008; National Research Council, 2001).

For these reasons, the launching of the CCSS-M brought attention to the need for teacher professional development (PD) and support from all stakeholders to understand these new standards and see the value of their implementation (Sztajn, Marrongelle, Smith, & Melton, 2012). Although not exclusive to mathematics, educational policies support PD. An estimated $20 billion of local, state, and national funds is spent on PD each year (Guskey & Yoon, 2009). According to the US Department of Education, Title II provides funds for evidence-based PD intended to improve teacher quality; however, little is known about the outcomes. In addition, little is known about the majority of PD provided to teachers due to the fact that most opportunities are not reported (Sztajn, 2011). This is because most PD is locally planned and implemented.

Embedded PD

Darling-Hammond and colleagues' (2017) described different types of PD. Embedded PD is integrated into daily practice (e.g., team planning) while external PD is not (e.g., workshops or conferences). Although external PD can provide useful information about teacher learning, this study is focused on teachers' embedded experiences. In this study, embedded PD is defined as opportunities in the school day that teachers have to learn about the mathematics they teach. The literature provides evidence that embedded PD occurs through a teacher's individual actions and through interactions with colleagues.

Individual actions create embedded PD opportunities for teachers. Researchers have pointed to how teachers' instruction can change over time and become higher quality with experience (Papay & Kraft, 2015). As an instructional strategy or tool is implemented in the classroom, a teacher might make modifications or increase the frequency of its use based upon ongoing self-reflection and consideration of how students respond. In addition to experience and reflection, a teacher's individual actions with curricular materials can create embedded PD opportunities. For example, a study showed that a teacher's instruction became more student-centered from reading the teacher guide included with the Standards-aligned textbook (Collopy, 2003). Interactions with colleagues also create embedded PD experiences for teachers. For example, teachers reported a change in instruction after getting informal advice from another teacher (Parise & Spillane, 2010). In another example, Bauml (2014) said that teachers planning together impacted how a first-year teacher taught mathematics. Collectively, these articles suggest teachers can create their own embedded experiences by engaging in teaching and planning activities. Although it is likely these experiences contribute to teacher learning and influence mathematics instruction, this study focuses on collaborative experiences that are embedded within the school day through Professional Learning Communities (PLC) and coaching experiences.

Professional Learning Communities

Professional Learning Communities (PLC) have been noted as the most effective type of PD (DuFour & DuFour, 2013). Darling-Hammond, Wei, Andree, Richardson, and Orphanos, (2009) describe this as "a new paradigm" of teacher learning that moves away from traditional disconnected experiences to learning communities engaged in inquiry around practice. PLC meetings embrace a collegial setting where teachers focus on specific goals to improve student learning (DuFour & DuFour, 2013). Although PLC seems to be the most commonly used term, the idea of teachers learning in this type of environment is not exclusive to PLCs. For instance, communities of practice were described by Wenger (1998) as groups of people that meet to share ideas and learn from each other. In the same way, critical friend groups aim to develop teaching practice through collaboration among teachers helping each other develop solutions for their problems (Darling-Hammond & McLaughlin, 1995; Kuh, 2014).

Developing teachers' practice is also the goal of PLCs which serves as an environment of continuous improvement where the work is guided by student learning (DuFour, Eaker, & DuFour, 2005). The idea is that teachers will develop innovative ideas to meet students' learning needs and then be able to try out their ideas in their classroom before meeting again to discuss the outcome (DuFour & DuFour, 2013). PLCs are most successful in schools with supportive leadership and common values and vision (Hord & Sommers, 2008). This is probably because learning in this way requires teachers to give and accept constructive criticism. Some studies have found that PLCs differed due to teacher characteristics. In one example, Nickerson and Moriarty (2015) concluded that teachers that get along were more likely to work toward school-wide goals. In another study, teachers with more years of experience focused more on student learning than novice teachers (Horn & Kane, 2015). For this reason, it is likely that PLCs look different from school to school.

Coaching

Individual and team coaching can support teachers' instruction with a coach taking on various roles such as data coach, resource provider, mentor, and curriculum and instructional specialist (Knight, 2009). There are also various coaching methods that include cognitive coaching, content-focused coaching, and peer coaching (Killion, 2012). Regardless of the approach, providing support for mathematics instruction requires specific skills, knowledge, and time to engage teachers in meaningful activities (Campbell & Griffin, 2017). In 2006, then NCTM president Skip Fennell urged schools to provide teachers with the support they need by hiring school-based mathematics specialists [coaches]. The research generated since 2006 supports his claim (Campbell & Malkus, 2011; Hopkins, Ozimek, & Sweet, 2017). Due to the fact that mathematics specialists receive unique training to prepare them to support mathematics learning by working with students, teachers, and school leaders (Association of Mathematics Teacher Educators, 2013, it is likely that some coaches are more prepared than others. Although there is evidence that many US elementary teachers have access to coaching, the type of coaching they experience is unclear (NSSME; Horizon Research, 2018). For that reason, it can be assumed that coaching opportunities vary.

PD Activities

As previously mentioned, PLC meetings and coaching opportunities are likely to vary between schools. To exemplify possible differences, consider the two scenarios shown in Table 5.1. Both scenarios describe the same two teachers' experiences in PLC meetings. In the first scenario, it seems that the teachers have similar PLC experiences. That is, both teachers work collaboratively with other teachers and a coach during weekly PLC meetings. In contrast, the experiences seem quite different in the second scenario. That is, the teachers engage in different types of activities during their PLC meetings. In this example, Teacher A engages in more activities that focus on mathematics than Teacher B. This illustration can be used to justify the need to investigate not only the type PD in which teachers engage, but also the activities that occur during PD.

Table 5.1
Two Scenarios

Scenario 1 Teacher A and Teacher B participate in weekly PLC meetings that is attended by a school-based coach. Both PLCs discuss mathematics and work collaboratively on lessons and activities to use with students.
Scenario 2 Teacher A engage in weekly PLC meetings that is attended by a school-based coach that specializes in mathematics instruction. The coach facilitates conversation around student work using progression documents. Teachers are often prompted to think about mathematics from the perspective of their students and reflect on the differences between doing and teaching mathematics. About monthly, teachers have the opportunity to practice an instruction method that promotes Standards-aligned instruction. It starts by using PLC time to watch a video that exemplifies the specific instructional method such as using questioning to elicit student thinking. Teachers then try incorporating the method into their instruction before meeting again to reflect on their experiences. Teacher B engages in weekly PLC meetings that is attended by a school-based coach that provides support for all content areas. Ideally half of the time spent in PLC focused on ELA and half on mathematics. However, the teachers spend more time talking about ELA because according to test data, many of their students do read on grade-level. When they do talk about mathematics, the majority of time is spent sorting students into remediation groups.

The National Research Council (NRC, 2001) suggested that mathematics-focused PD should incorporate activities to develop teachers' understanding of content, pedagogy, and student learning. This recommendation is also evident in existing research that indicates PD is more effective if it addresses content, pedagogy, and student learning (Heck, Banilower, Weiss, & Rosenburg, 2008; van Es & Sherin, 2010). This study used the NRC's recommendation along with other research studies to sort the activities teachers engage in during PD opportunities into three categories. *What to Teach* (W) are focused on content activities, *How to Teach* (H) are focused on pedagogical activities, and *Why Teach This Way* (Wy) are activities focused on student learning. Although this study is not attempting to evaluate teachers' PD experiences, it is assumed that participating in WHWy simultaneously increases the potential to learn about Standards-aligned instruction (NRC, 2001; van Es & Sherin, 2010; Heck et al., 2008).

What to Teach

Empirical studies show teachers engage in activities focused on planning instruction. Some of the examples describe the work of university-based teacher educators (Chval, Pinnow, & Thomas, 2015; Geiger, Muir, & Lamb, 2016). In one example, Polly (2012) collected data as he provided ongoing coaching support to four teachers. During the study, the author co-planned lessons and provided teachers with instructional resources to use during instruction. These studies are helpful in understanding activities that might influence instruction. However, the majority of teachers do not have the opportunity to work one on one with a researcher. It is more likely for teachers to co-plan with school-based coaches (Campbell & Malkus, 2011) or with other teachers (Bauml, 2014; Althauser 2015). Planning instruction can also include revising or rewriting previously taught lessons (Suh & Seshaiyer, 2015; Murata, Bofferding, Pothen, Taylor & Wischnia, 2012) or unpacking a lesson from a provided textbook (McGee, Polly, & Wang, 2013). Some teachers might discuss which manipulatives and games would best fit into a lesson (Bauml, 2014) while others might work together to select activities or materials to use with students (Borko, Mayfield, Marion, Flexer, & Cumbo, 1997; Hunter & Hall, 2008; Forte, Humphreys & Park, 2012; Stein & Coburn, 2008; Stein, Smith & Hughs, 2008; Baxter, Ruzicka, Beghetto & Livelybrooks, 2014).

How to Teach

Empirical studies show two ways in which teachers engage in activities focused on how to teach. The first is by taking a student perspective. During embedded PD, this would happen when a coach or teacher models an instructional strategy by facilitating a student lesson with a group of teachers. This means the person modeling instruction assumes the role of a teacher and the others engage in the lesson as a student. In one example, PD focused on cognitively demanding tasks engaged teachers in lesson at the start of each session which allowed the facilitator to model how tasks are implemented in the classroom (Polly, Neale, & Pugalee, 2014). The PD had a significant impact on teachers' knowledge and beliefs; however, there were only minor changes in teachers' instruction. This suggests that knowledge and beliefs change before instruction changes. Other study showed this type of participation may confront teachers' beliefs (Zwiep & Benken, 2013). As facilitators modeled a collaborative learning environment that engaged teachers in a problem-solving task some teachers became aware that they lacked conceptual understanding. Although the authors reported a decrease in teachers' confidence, the experience might have sparked a purpose for continued learning. It is also possible that participating in a lesson as a student will show no impact. While engaging in problem-solving task with other teachers, Battey and Franke (2008) reported that one particular teacher who believed mathematics is a collection of steps and formulas tended to solve tasks by using the exact methods she saw other participating teachers use. She seemed to miss the purpose of the activity as she bragged about how quickly she finished. In comparison, another teacher who lacked confidence solved the problem without engaging with others in the group. Later, this participating teacher admitted that he did not want his co-workers to know that he did not have a good understanding of mathematics. Collectively these studies show teachers participate in lessons facilitated by another adult and that various factors may impact their experience.

The second way in which teachers engage in activities focused on teaching is by observing and practicing instructional strategies. One such example of this type of PD is participation in lesson study. Although lesson studies can be implemented differently, in general it involves a group of teachers planning a lesson together, observing one of the participants teach the lesson, reflecting and making improvements to the lesson, and then watching another participant teach the lesson. Engaging in a lesson study with teachers from other grade-levels support teachers to make connections between content and representation (Fernandez, 2005; Suh & Seshaiyer, 2014). Moreover, observing how students respond to instruction before teaching the lesson can increase the amount of attention a teacher places on student learning when she implements the same lesson (Murata, Bofferding, Pothen, Taylor, & Wischnia, 2012). Videos can also provide teachers with opportunities to observe instruction. In one example, videos were used to highlight how questioning can be used to engage students in a lesson (Santagata, Kersting, Givvin & Stigler, 2011). These experiences are important because teachers are sometimes uncertain about what instruction should look like and question if they are doing it correctly (Stickles, 2011).

Why Teach this Way

To understand the why of teaching, teachers engage in activities focused on how students learn and understand mathematics. The literature shows that some teachers spend time analyzing student work (Garet et al., 2016; Kazemi & Franke, 2004). In one example, teachers were asked to think about and explain incorrect responses (Santagata, Kersting, Givvin, & Stigler, 2011). Videos can also be used to lead discussions around student thinking. Research has found that teachers' conversations become more focused on student understanding after participating in PD anchored around discussions about videos of classroom instruction (van Es & Sherin, 2010; van Es, 2012). Other activities provide teachers time to make sense of the Standards. For example, teachers participating in a district-led PD developed a curriculum by first examining Standards and then compiling resources that were aligned (Althauser, 2015). *Why* activities also include reflection prompts when PD facilitators ask participating teachers to reflect on a particular topic. For example, when learning to understand how children's thinking develops, teachers were asked to reflect on student work samples that showed intuitive solution strategies (Fennema, Franke, Carpenter, & Carey, 1993).

Table 5.2
PD Activities Sorted by WHWy Focus

What to Teach (content)	**How to Teach (pedagogy)**	**Why Teach this Way (student learning)**
• Planned mathematics instruction. • Solved the mathematics problems that would be used during a future lesson. • Differentiated or modified mathematics lesson plans. • Planned which games or manipulatives to use during a lesson.	• Observed instruction (video or live). • Watched a video of own mathematics instruction. • Practiced instructional methods. • Received feedback after a mathematics lesson observation. • Engaged in a lesson as a student.	• Analyzed student mathematics work. • Listened to students explain their thinking. • Discussed common solution and errors. • Discussed progression. • Engaged in self-reflection.

In summary, teachers participate in embedded PD by participating in PLC meetings and coaching opportunities. Moreover, teachers engage in activities that focus on content, pedagogy, and student learning (WHWy activities; See Table 5.2). It could be assumed that PD experiences vary due to things like the frequency of participation and focus of the activities. In the same way, it is likely that school context stimulates differences in embedded PD.

School Context

School context includes circumstances specific to a school such as its location and characteristics of the people in the school community (e.g., teachers, students). Additionally, school context can be described by the expectations set by the school principal (e.g., the amount of time spent on mathematics instruction and which teachers are selected to attend external PD).

Therefore, it could be assumed that principals' decisions will impact embedded PD opportunities. Decisions about the school schedule might explain some of the variations in opportunities to engage in embedded PD. For example, principals determine the time allotted for PLC meetings. Some schools have set times while other schools may have a more sporadic schedule (Stein & Coburn, 2008). The schedule can also provide teachers with time during the school day to collaborate with other teachers. Bauml (2014) described how a new teacher used daily planning to work with other teachers about mathematics.

It is also likely that principals make decisions about which resources are provided to teachers and set expectations about how the resource is used. For instance, some schools provide teachers with a Standards-aligned curriculum (Harmon, Gordanier, Henry & George, 2007; Stein & Coburn, 2008; Stickles, 2011). However, teachers often enact lessons differently than Standards-aligned textbook suggests (Brown; 2009; Sherin & Drake, 2009). Therefore, it seems that providing a resource should be accompanied by opportunities to discuss and understand how the resource can support Standards-based instruction. Although these examples focus on textbooks, it can be assumed that other resources such as manipulatives and games would also require PD. Decisions around hiring and assigning roles for instructional coaches are also left up to the principal. Neufeld and Roper (2003) found that a principal's beliefs influenced the role of instructional coaches. Another study showed when hiring and training an instructional coach, a principal should be aware of the specialized required to support mathematics instruction skills (Gibbons & Cobb, 2016). As described here, school context might impact embedded PD opportunities.

The implementation of the CCSS-M has shifted the expectations of instruction. Embedded PD provides teachers opportunities to develop the knowledge and skills needed to meet such expectations. It is likely that many teachers participate in embedded PD; however, there is little research on their experiences. For that reason, this study seeks to provide the field with information about teachers' opportunities to participate in embedded mathematics-focused PD. The study, focused on K-5 teachers working in ten schools in the same district, was guided by the following research questions:

1) From the perspective of teachers working at 10 elementary schools in the same district, what are the similarities and differences in their mathematics-focused learning opportunities that are embedded in the school day?
2) What additional information can school documents and interviews with school leaders provide when trying to understand the relationship between school context and teachers' embedded learning opportunities?

Methodology

Context

A partnership with a school district in the southeastern United States was made by meeting with the director of research and the director of PD. A proposal was shared with the district and approved by the district cabinet. The district agreed to endorse the study by encouraging all elementary teachers and principals to participate. The district includes schools that serve suburban towns on one side to much more rural areas on the other side. There are approximately 37,000 students in the district at 45 schools (i.e., 23 elementary schools). An increase in population has doubled the number of students in the district over the past 15 years. Students are ethnically diverse (52% White, 25% Hispanic, 16% African American, 5% multiracial, and less than 1% Native American and Pacific Islanders) and represent 69 different countries.

It is relevant to note that instruction in the district is based on the state Standards. Like many other US schools, the district implements a Multi-Tiered System of Supports (MTSS) Instructional Framework to support students' individual academic and behavioral needs (See Figure 5.1). This means teachers provide mathematics instruction that address grade-level standards (Tier 1) and interventions (Tier 2 and 3) that address specific learning needs of students.

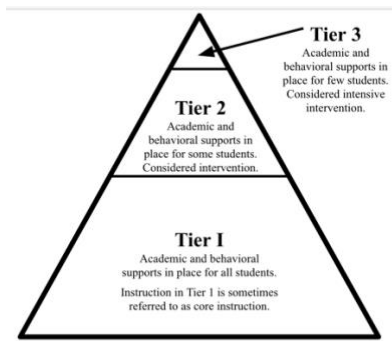


Figure 5.1. *The MTSS framework adapted from the description on the district's website.*

Study Design

This study employed a sequential mixed methods design (quan → QUAL; Creswell & Plano Clark, 2017) that consisted of two phases. During phase 1, quantitative data was collected from teachers that agreed to participate by completing a survey about their PD experiences during the 2018/19 school year. As an incentive to complete the survey, which took about 10-20 minutes, participants were eligible to enter a drawing for one of thirty-five $15 gift cards. The link remained active for seventeen days with reminders being sent on days two, seven, and sixteen. School principals were sent emails to encourage participation two times during data collection. An estimate of 630 teachers were determined to be eligible to participate by subtracting the district's average turnover from the number of mathematics teachers per school. There was a 28% response rate with data collected from 178 teachers. The data collected from the teachers prompted the design of phase 2. During phase 2, qualitative data was collected from school leaders at two of the district's elementary schools. In this study, the qualitative data was given precedence.

Table 5.3
Visual Model for Mixed-Methods Sequential Explanatory Design

Phase	Procedures	Products
Quantitative Data Collection	• Recruit participants • Administer web-based survey	
Quantitative Data Analysis	• Descriptive Statistics	• Embedded PD Score • School Context Score • Frequencies
Case Selection	• Determine criteria for selecting two schools	• Criteria for participant selection • Semi-structured interview questions
Qualitative Data Collection	• Recruit six school leaders • Conduct interviews • Obtain copy of school improvement plan	• Transcripts
Qualitative Data Analysis	• Thematic content analysis	• Coded transcripts • Code book • Findings for Case One • Findings for Case Two • Cross Case Analysis

Qualitative Phase 1

Phase 1: Participants

Although data was collected from 174 teachers working in 23 of the district's elementary schools, this study reports the data collected from teachers working at schools that had at least 25% of eligible teachers complete the survey. This resulted in 106 teachers in the sample who worked at ten different elementary schools, represented each grade-level from kindergarten through fifth-grade, and had a range of teaching experience. Table 5.4 provides a summary of characteristics of each school and teachers within each school.

Table 5.4

Descriptive Characteristics of Phase 1 Participants by School

School Name (Pseudonym)	Title 1	Years of Teaching Experience			Grade Level 2018/19						Highest Degree		EMS
		Less than 5	5-14	More than 15	K	1	2	3	4	5	B	M	
Abbot Elementary School (AES)	Y	1	3	2	2	1	2	1	2	0	3	3	0
Blackwell Elementary School (BES)	Y	1	4	1	3	1	1	1	1	1	5	1	0
Curie Elementary School (CES)	N	1	5	0	1	1	1	3	0	0	5	1	0
Hopper Elementary School (HES)	N	3	5	11	2	6	3	4	3	1	10	9	1
Jackson Elementary School (JES)	Y	1	2	2	2	0	0	2	2	0	5	0	2
Kennedy Elementary School (KES)	Y	0	2	4	2	1	3	2	1	0	4	1	0
Lincoln Elementary School (LES)	Y	6	3	2	2	2	4	1	2	4	11	0	0
Madison Elementary School (MES)	Y	1	3	2	2	1	2	0	2	0	4	2	0
Parks Elementary School (PES)	Y	6	2	0	1	0	2	5	3	0	7	1	1
Smith Elementary School (SES)	Y	3	7	4	3	3	4	2	2	2	13	1	0

Note. Information on table reports data collected from the participants that answered demographic items. Y=yes to Title 1 Status; N=no to Title 1 status; B=bachelor's degree; M=master's degree; EMS=Elementary Mathematics Specialist License (has or is in the process of obtaining).

Phase 1: Quantitative Data Collection

TLO-M survey. The Teachers' Learning Opportunities in Mathematics (TLO-M) was used to collect data during the quantitative phase of this study. The TLO-M is a web-based survey in which elementary teachers report on their mathematics focused PD opportunities. Validity evidence was collected through an expert review, three rounds of cognitive interviews, and a pilot study. First, experts guided the development and determined that the TLO-M provides data for the intended purpose of reporting teachers' learning opportunities. Second, data from multiple rounds of cognitive interviews directed changes and confirmed the TLO-M items were understood as intended and matched teachers' experiences. Lastly, the pilot test confirmed that experiences align to the events and activities found in the literature. That is teachers participate in embedded, external, and self-directed PD and engage in activities from each WHWy category.

Phase 1: Data Analysis

Descriptive statistics and frequencies were used to compute TLO-M scores to address the first research question: From the perspective of teachers working at 10 elementary schools in the same district, what are the similarities and differences in their mathematics-focused learning opportunities that are embedded in the school day? The phase 1 analysis focused on TLO-M data from 106 teachers at 10 schools. The survey data was examined for quality (e.g., check to make sure data was in expected range, look for missing data) and inspected for errors (e.g., summary statistics, visualizations). Then, the data was manipulated to create new variables needed to calculate scores (e.g., activity points, combined frequencies). Finally, scores were calculated, and descriptive statistics were examined.

Embedded frequency score. The embedded frequency score (EMF) is the combined value of the four PLC and coaching frequency items (See Table 5.5). EMF ranges from 0-20. Zero indicates no opportunities to participate in PLC or coaching and 20 indicates daily participation in team and individual coaching as well as grade-level and vertical PLC meetings.

Table 5.5
Embedded Frequency Score

Purpose	Items	Value of Response Options
Determine frequency of embedded PD	1. About how often did you receive individual coaching from a mathematics coach? 2. About how often did you receive team coaching from a mathematics coach? 3. About how often did you participate in grade-level mathematics PLC meetings? 4. About how often did you participate in vertical mathematics PLC meetings?	0=never 1=a few times per year 2= about quarterly 3= about monthly 4=about weekly 5= about daily

Embedded activity score (EMA). The embedded activity score (EMA) is the combined value of the PLC activity points and coaching activity points. The TLO-M items are displayed in Figure 5.2. Notice that the *How to Teach (student perspective)* item acts as a filter question. This format is used so teachers are only asked questions that are relevant to their experiences. Activity points range from 0-5. As shown in Figure 5.2, bolded italicized font shows the response used to determine the point for the *How to Teach (student perspective)* category. Points for the other categories are determined by answering yes to any question in a given category.

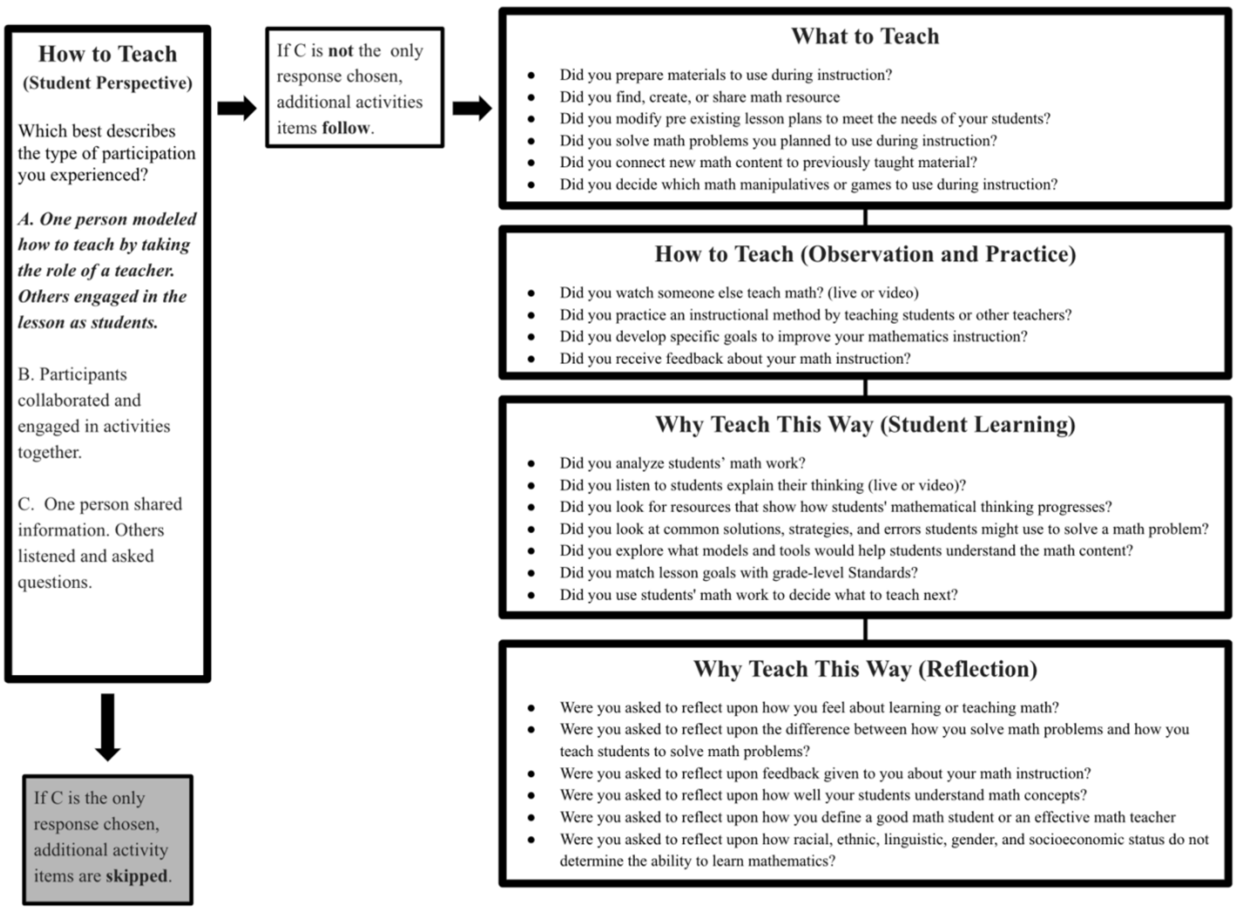


Figure 5.2. WHWy flowchart.

School context score (SCS). The school context score ranges from 0-9 with one point given for each of the following conditions: (1) the school provides a lesson plan resource, (2) the school provides Standards, (3) the school provides manipulatives, (4) the school provides a pacing guide, (5) teachers are provided with a daily planning period, (6) school leaders (always or often) attend PLC meetings, (7) coaches (always or often) attend PLC meetings, (8) the role of the instructional coach is to support teachers' mathematics instruction (rather than supporting all content areas), and (9) PLC meetings take place during normal work hours.

Phase 1: Quantitative Results

Descriptive statistics and frequencies were used to compute TLO-M scores to address the first research question: From the perspective of teachers working at 10 elementary schools in the same district, what are the similarities and differences in their mathematics-focused learning opportunities that are embedded in the school day? Table 5.6 presents the descriptive statistics for the embedded frequency (EMF), embedded activity (EMA), and school context (SCS) mean scores by school.

Table 5.6
Descriptive Statistics by School

School Name (Pseudonym)	N	Mean Frequency Scores			Mean Activity Scores			Mean SCS
		EMF Score	PLC	Coaching	EMA	PLC	Coaching	
Abbot Elementary School (AES)	8	7.88	5.50	2.38	1.88	1.88	0	4.88
Blackwell Elementary School (BES)	8	4.71	4.71	0	2.29	2.29	N/A	4.38
Curie Elementary School (CES)	6	5.17	3.33	1.83	4.20	3.40	1.33	6.33
Hopper Elementary School (HES)	19	5.11	3.79	1.32	2.06	1.75	0.78	4.37
Jackson Elementary School (JES)	6	6.67	4.67	2.40	3.40	3.40	N/A	5.00
Kennedy Elementary School (KES)	9	5.86	4.88	1.00	3.13	3.13	0	4.22
Lincoln Elementary School (LES)	15	6.25	3.33	3.18	2.00	2.00	0	5.33
Madison Elementary School (MES)	7	5.57	4.29	1.5	3.14	2.49	5	6.00
Parks Elementary School (PES)	11	11.27	6.00	6.44	2.91	2.45	0.56	6.18
Smith Elementary School (SES)	17	7.06	4.75	2.47	2.67	2.33	0.56	4.82

Note. N/A means no teacher at the school answered the activity items.

Embedded Scores. In this study, the average EMF scores ranged from 4.71 to 11.27. This indicates variation in embedded opportunities. The results also suggest that more teachers participate in PLC meetings than in coaching opportunities (e.g., lowest mean for PLC frequency=3.33; lowest mean for coaching frequency=0). Similarly, there is variation in the EMA scores which ranged from 1.88 to 4.20. Considering that half of the schools do not have any coaching activity points, it is reasonable to assume that more teachers engage in activities focused on WHWy during PLC meetings than during coaching.

School Context Score. In this study, the mean SCS ranged from 4.22 to 6.33. It is important to interpret this range with caution because these are mean scores across teachers within a school. Therefore, a more detailed display of the item-level SCS data by school is warranted. Table 5.7 displays the percent of respondents from each school that answered yes to each condition. The table is also coded to show high and low agreement. The boxes shaded black and light grey represent more agreement than the dark grey boxes. Specifically, the black boxes represent the instances that less than 30% of the teachers answered yes and the light grey boxes represent the instances that more than 70% of the teachers answered yes. Both can be thought of as at least 70% agreement between teachers in the same school. Notice that all the school have high agreement in three areas: providing manipulatives, PLC meetings occurring during the workday, and not having instructional coaches that focus solely on mathematics. More interestingly, the dark grey boxes represent the instances that were between 30 and 70%. This can be interpreted as items on which there was less agreement among teachers in the same school. Many of the dark grey boxes appear in areas that ask about provided resources. This means some teachers said the school provided Standards, pacing guides, and lesson plans, and some teachers said the school did not provide such resources. This finding is surprising because the district's website lists "Instructional Excellence & Alignment" as the first objective under their strategic plan. However, this study shows potential misalignment due to the sharp contrast between teachers' responses to school provided resources. Further research is needed to determine what resources are provided by the district and how the expectations of resource use are communicated from the district to principals and from the principals to the teachers in the schools.

Table 5.7
Percent of Responses Per School (School Context Points)

	Schools									
	AES n=8	BES n=8	CES n=6	HES n=19	JES n=6	KES n=9	LES n=15	MES n=7	PES n=11	SES n=17
School Provided Standards	63%	63%	83%	58%	50%	33%	87%	71%	73%	75%
School Provided Pacing Guide	63%	25%	50%	32%	17%	22%	27%	71%	73%	50%
School Provided Lesson Plans	63%	63%	100%	32%	17%	56%	73%	43%	55%	56%
School Provided Manipulatives	87%	75%	100%	89%	100%	89%	100%	100%	91%	94%
Daily Planning Period	87%	75%	100%	84%	67%	67%	100%	100%	55%	63%
School Leaders (always or often) Attended PLC Meetings	25%	100%	83%	16%	83%	33%	67%	57%	82%	63%
Instructional Coach (always or often) Attended PLC Meetings	13%	0	17%	37%	83%	22%	60%	57%	91%	19%
PLC Meetings Occur During School Hours	87%	100%	83%	79%	83%	78%	73%	100%	91%	88%
Instructional Coach (mathematics focus)	0	0	17%	16%	0	0	13%	0	0	0

Case Selection

Data collected during phase 1 of the study was used to determine the participants in phase 2 of the study. Table 5.8 compares the schools with the four highest SCS. SCS scores were used because it was assumed that schools with higher SCS scores might have school leaders that value mathematics. Notice that LES and MES have similar SCS and EMF scores but contrasting EMA scores. More interestingly, the LES coaching frequency score is high (M=3.18) but the coaching activity score is low (M=0). In contrast, the MES coaching frequency score is low (M=1.5) but the activity score is high (M=5). This suggests that LES teachers interact often with a coach but do not engage in activities focused on WHWy. In comparison, MES teachers seem to interact with a coach less often, however, the encounters include activities from each WHWy category. For this reason, these two schools were chosen for phase 2. It is worth mentioning that the other schools also stood out (PES has the highest EMF score and CES has the highest EMA score). Although it would be interesting to find out more about these school, PES and CES were not chosen for phase 2. PES was not chosen because the researcher was previously employed at the school as a teacher and mathematics curriculum coach. CES was not chosen because the school principal indicated a lack of interest in the study during phase 1.

Table 5.8
Top Four Schools (SCS)

School Name (Pseudonym)	N	Mean Frequency Scores			Mean Activity Scores			Mean SCS
		EMF Score	PLC	Coaching	EMA	PLC	Coaching	
Curie Elementary School (CES)	6	5.17	3.33	1.83	4.20	3.40	1.33	6.33
Lincoln Elementary School (LES)	15	6.25	3.33	3.18	2.00	2.00	0	5.33
Madison Elementary School (MES)	7	5.57	4.29	1.5	3.14	2.49	5	6.00
Parks Elementary School (PES)	11	11.27	6.00	6.44	2.91	2.45	0.56	6.18

Note. N/A means no teacher at the school answered the activity items.

Qualitative Phase 2

Phase 2: Participants

Data was collected from six school leaders working at two of the district's elementary schools. Participants from Lincoln Elementary School (LES) included the principal, assistant principal (AP), and one instructional coach. Participants from Madison Elementary School (MES) included the principal and two instructional coaches. Table 5.9 shows pseudonyms used for each phase 2 participant.

Table 5.9
Pseudonyms for Phase 2 Participants

School (Pseudonym)	Participant (Pseudonym)	Role
Lincoln Elementary	Principal Alex	Principal
Lincoln Elementary	AP Lee	Assistant Principal
Lincoln Elementary	Coach Jamie	Instructional Coach
Madison Elementary	Principal Carson	Principal
Madison Elementary	Coach Jordan	Curriculum Coach
Madison Elementary	Coach Lane	MTSS Coach

Phase 2: Qualitative Data Collection

For phase two, qualitative data was collected through semi-structured interviews with school leaders and document analysis of school improvement plans. An email was first sent to the principals of Lincoln and Madison Elementary Schools. After principals agreed to participate, invitations to participate were sent to assistant principals (AP) and curriculum coaches. Due to one AP being new to the school, the former AP (still working in the district) was invited but declined the offer to participate. For that reason, interview data was collected from a principal, AP, and coach from LES and a principal and two coaches from MES.

Semi-structured interviews. The researcher met with each participant at a scheduled time to conduct a semi-structured interview during the months of October and November 2019. A semi-structured format was used to collect data from school leaders. The format is flexible enough to probe individuals on their perspective yet provides a level of consistency throughout the interviews (Merriam & Tisdell, 2016). The interview questions focused on mathematics instruction including questions about provided resources, expectations, PLC meetings, coaching opportunities, and external PD. The same questions were asked of each participant. However, the conversation guided additional prompts. Interviews were conducted in person and lasted between 55 and 80 minutes. Interviews were audio-recorded and transcribed by the researcher. It is important to note the audio recording malfunctioned during the interview with AP Lee. Therefore, detailed notes were written immediately after the interview and send to AP Lee to verify the conversation was captured accurately.

School improvement plan. According to state law followed by the district, schools are required to participate in the School-Based Management and Accountability Program. This includes designating a team of school members to develop a School Improvement Plan (SIP). The SIP was collected because it provides information about school initiatives. The SIP was obtained at the time of the interview with the school principal.

Phase 2: Qualitative Analysis

Interview data and the SIP were analyzed to answer the second research question: What additional information can school documents and interviews with school leaders provide when trying to understand teachers' embedded learning opportunities? Analyzing qualitative data is an iterative process (Creswell, 2018). This means making sense of the data is a continuous process that includes coding and reading several times. The process started by writing a memo after each interview. The next step was transcribing and coding the data. The coding process included sectioning the data by interview question, coding each section sentence by sentence, grouping initial codes, deleting repetitious codes (e.g., textbook, Investigations), and developing themes. The analysis in phase two was designed to explore how school context might influence teachers' learning. The analysis was performed at two levels: within each case and across the cases.

Phase 2: Qualitative Findings

The qualitative strand of this study was used to answer the second research question: What additional information can school documents and interviews with school leaders provide when trying to understand the relationship between school context and teachers' embedded learning opportunities? Results from the qualitative data indicated that principle's influence PD decisions and opportunities. The results are presented in three sections (1) The Case of Lincoln Elementary, (2) The Case of Madison Elementary, and (3) Between Cases.

The Case of Lincoln Elementary

Background

Lincoln Elementary School (LES) serves 570 K-5 students in a rural area within the district. Classroom teachers at LES are responsible for teaching all subjects. The leadership team includes the principal, assistant principal (AP), and three instructional coaches. For this study, the principal (Principal Alex), assistant principal (AP Lee), and one instructional coach (Coach Jamie) were interviewed. Of the three instructional coaches, Coach Jamie was selected because of her background in mathematics education. In addition to her position as an instructional coach, Coach Jamie teaches mathematics education courses at a nearby university

Principal's Expectations

Principal Alex started at LES a little over two years ago, and since then, the team has focused on creating a collaborative school culture, which they describe as a place where everyone learns from each other. Principal Alex articulated a clear vision by describing how he is strategically making decisions to cultivate such collaboration. This includes being transparent with the choices he makes and providing time for teachers to trust him. The team acknowledges that shifting the culture from being compartmentalized to synergistic is a process that takes time.

AP Lee emphasized how different the expectations are since Principal Alex arrived, and the teachers are just getting used to the idea that talking to administrators does not mean they are in trouble. The team agrees that change is slow, but the culture is shifting, and instruction is improving.

Model expectations. The LES school improvement plan states, “We value strong team culture with representation of all stakeholders. We focus on effective metrics to produce sustainable results over time.” This mission seems to align well with the work the school leaders are doing as they try to shift the school to have a more collaborative culture. The task has been quite an undertaking. Principal Alex said, “shifting to a culture of coaching and thinking is hard work.” The group tries to model the collaborative expectations of the school’s vision with communication between the school leaders considered a priority. The expectations of each person’s role on the leadership team is not set; instead Principal Alex explained the expectations are determined through “constant conversations.” He said, “we eat lunch together every day” and message each other at night to discuss what is happening in the school. For instance, they share what they observed on classroom visits or talk through how they might handle a potential problem. Principal Alex stressed how important it was to be surrounded by a team of professionals that push each other to be their best. He said, “I know I sit in the principal seat and I'm the boss of the school, but I have built a team around me that will question everything.” He explained that they are very honest with one another and have no problem critiquing ideas. He said, “We lose our titles at the door... we are all in this together.”

Visit classrooms. Principal Alex expects for the school leaders to know what is happening classrooms. Therefore, the leadership team visits classrooms often. In addition to the time they spend in classrooms during planned observations and meetings, each of the leader participates in daily morning meetings. Morning meetings are listed as a strategy on the school improvement plan and according to coach Jamie, the purpose of the meetings is to "address the social and emotional learning needs of our kids." Being in and out of classrooms also allows the leaders to observe instructional methods which they highlight in a weekly newsletter. Coach Jaime said it promotes collaboration because "somebody might want to talk to another teacher about what they are implementing." Additionally, teachers are encouraged visit other classrooms to observe instruction. Principal Alex said teachers can set up an observation any time. He laughed and said, "If they have someone they want to see, we agree. But sometimes they'll just want to go see a friend." He guides the choices by saying things like, "you should go watch (teacher's name) because your personality is more like hers or you know who's really good?"

Embedded Learning through Coaching

Coaching role. Principal Alex reported that the coaches have a lot of freedom in choosing how to spend their time. He said he does not want to define the role because it might keep them from trying "out of the box" ideas. He went on to say that he knows what they are doing because he is "very much in it with them all the time." In other words, the communication between the team allows everyone to be on the same page. Keeping with the collaborative culture, the instructional coaches share an office and the school schedule includes a weekly time for coaches to work together. Principal Alex made this decision so that coaches would "leverage each other" and support each other to get better. Coach Jamie explained that the coaches, "talk about things that have happened over the week, needs that we are seeing, what we need to do the upcoming week. Kind of get a game plan for where we're going."

There are some expectations for the coaches. AP Lee said that the coaches are not assigned any extra duties that take away from the time that can be spent with teachers. Moreover, each coach is assigned to work with two grade levels and provides support in all areas. However, because the team sees Coach Jamie as the mathematics expert, it is common for coaches and teachers to go to her with questions pertaining to mathematics.

Coaching style. The leadership team all have been trained to use a specific coaching method. The method is called Cognitive Coaching (CC), and it is designed to develop self-directed teachers through reflection and problem solving. Principal Alex explained why he thinks this coaching style works. He said, "You can tell people stuff all day long. That's like what I did before I ever understood Cognitive Coaching. I tell you something and if you don't believe it in your heart the next time, we're right back at this situation. Cognitive coaching is about shifting their thinking." Coach Jamie explained that CC shifted the way she responds to teachers when they ask for advice. In the past, she might have provided help by telling teachers what she would do in a certain situation. Now instead of giving advice, she guides teachers to come up with their own solutions. For example, she asks questions like, "What have you tried so far? What happened? And how was it different than you expected?" She laughed and remembered that when she first started using CC, some teachers would say just "tell me the answer." Principal Alex recalled a similar experience and reflectively added that some teachers would prefer if he just told them what to do but "that would take away their opportunity to learn." This style of coaching may explain the data collected from the teachers that showed there were many coaching opportunities, but no activities focused on any WHWy category. It seems that this coaching style guides teachers instead of leading them in planned activities.

Embedded Learning during PLC Meetings

Expectations. CC also guides conversations during weekly PLC meetings which is attended as often as possible by each member of the leadership team. This aligns with what teachers reported during phase 1. That is school leaders and coaches often or always attend PLC meetings. A couple of years ago the conversations that took place during PLC meetings seemed much less productive. Principal Alex admitted that during his first year, he was shocked at the lack of productivity. He asked his coaches, "Why are we not talking about planning and assessments?" In other words, Principal Alex wanted teachers to talk about their successes and failures of instruction and student learning, which was different than just talking about pacing or sharing lesson ideas. However, the instructional coaches helped him understand that the former administration did not have the same expectations for PLC meetings, so time was needed to develop an understanding of the new way of doing things. Principal Alex said, “teachers feel insecure about talking about their data” because they are not confident with their mathematics instruction. Principal Alex admitted, “I did not push as hard as I wanted that first year.” Conversations slowly started taking place during his second year. Principal Alex said it was a lot about “digging into those file cabinets and talking about what we are putting in front of kids.” He recognized that this was not easy for teachers and some would say, “but I have done this for the past ten years.” Principal Alex said it was hard to admit but the reality was teachers were not using materials that were aligned to the Standards. Through the work, Principal Alex was able to confront the use of misaligned resources by saying things like, “Here's the expectation [of the Standards], here's the stuff you're supplementing with.”

Strategy. One of the strategies listed in the 2018/19 LES School Improvement Plan states that the school would provide professional development “aligning tasks to state standards and district proficiency scales” which is incorporated into weekly PLC meetings. This means the leadership team used the district's initiative of Standards-based grading to guide the work done in PLC meetings. Principal Alex said, “we utilized the proficiency scales and started digging in.”

Coach Jamie remembered that the leadership team “found out quickly that the staff needed time to see what the proficiency scales were saying and what students are supposed to know by the end of the grade level.” In other words, they could tell that teachers did not have a solid grasp on the expectations set by the standards. Coach Jamie noticed how the conversations progressed throughout the year as teachers discussed how students learn. She said, “They were really cool conversations and it was very interesting as the year progressed seeing how teachers read and understood the proficiency scales.” Teachers would say things like, “We have this assessment but maybe we don’t use it for every student or maybe we can give the assessment and a performance task.”

AP Lee pointed out that the conversations were better but still not where they needed to be. Principal Alex reflected on the prior year and said, “We did a lot of benchmark assessments and not enough formative assessments.” The team continues to push teachers to be more collaborative by facilitating conversations around formative assessments. Principal Alex said the expectation is that all grade level use and discuss common assessments. However, he recently met with teams and asked, “Did you meet the expectation?” Just asking them “rocked their world” and “no PLC met the expectation.” Maybe teachers were not used to being held accountable. Principal Alex thinks teachers avoid talking about their data because of their insecurities with content knowledge. But PLC discussions might help because according to Principal Alex, the conversations, “gets teachers to look at depth of knowledge of a standard and the different verbs at different levels.”

Provided Resources

Lesson plan resource. There was agreement between the data collected during phase 1 and the interview data. That is teachers are provided with several resources to support mathematics instruction. One resource is the district provided curriculum, Investigations 3 Common Core Mathematics Program K-5, all the manipulatives required to teach the lessons, and any other supplies they request (e.g., dry erase markers). Since the curriculum adoption five years ago, the district has offered yearly PD. AP Lee said the school leaders usually send teachers that are struggling implementing the curriculum. Coach Jamie said, “I was fortunate enough to get to go sit in on most sessions with our teachers. So, I was hearing what they were hearing. And most of it was very similar year to year but they would still come back with some pieces that had not necessarily been brought back the year before because everybody hears things differently.” Although she “would not use the word fidelity” to describe how teachers at LES implement the curriculum, Coach Jamie said teachers have been using the curriculum pretty consistently. She added, “The communication and the discussion have gotten richer every year.” In fact, she credits the use of Investigations to the increase in student discourse, explaining that students have become accustomed to answering open-ended mathematics questions. She said, “We now have kids in the older grades that are very comfortable and used to the kinds of questions and the things that are being asked of them.” Principal Alex was not as convinced that the PD made a difference. He explained that the district training has changed over the years, specifically around the expectations of using the curriculum. At first everyone was told to “follow it with fidelity” but he continued “they moved away from that.” The message teachers leave with after attending PD has also shifted. According to Principal Alex, “even trainers for their own program were encouraging teachers not to follow it with fidelity.” He laughed and said, "it bit me in the butt" and explained that he sent teachers because he wanted them to follow Investigations as it is intended; instead, they were given permission to supplement.

Coach Jamie explained that teachers do not fully trust Investigations, which might be why they felt the need to alter the written lessons. AP Lee admitted that the lessons are different than what teachers have always done. Coach Jamie explained, "most teachers are now being asked to teach mathematics in ways that they did not learn it as a student themselves." This might be why Principal Alex thinks “It is scary to them.” He thinks teachers “need to see what effective questioning looks like and how to drive inquiry-based instruction in mathematics.” This influenced the choice to have a PD where the entire staff engaged in a problem-solving lesson facilitated by an external consultant. According to the leadership team, the PD prompted teachers to reflect on how they had been implementing mathematics lessons. Although some teachers were overwhelmed as they recognized the differences, Principal Alex thought it was just what they needed. He talked about the impact it had on one teacher. He said, “It was eye-opening, and it hurt a whole lot because she realized the things in the PD showed the expectation of rigor and thinking she wasn't ready to do. And it wasn't that she wasn't capable; she had not put in any time to get there.” He said the teacher vowed to read the books over the summer and “get in it.” He was pleased to announce that she really did, and her mathematics instruction is completely different than it was last year. Although some teachers may not be teaching the lessons as intended, the leadership team hopes that instruction will continuously improve when teachers are more willing to share about their teaching.

Pacing guide. Data collected during phase 1 showed that the majority of LES teachers said they were not provided with a pacing guide. However, that data might be different this year because teachers are required to use the curriculum as well as a common pacing guide. Principal Alex sees as this as a “game-changer” because common pacing keeps teachers from supplementing with resources that do not align with the expectations set by standards. Principal

Alex said, “Now when I come in for an observation, if you say you're on 1.3 of Investigations, then you shouldn't have something else out.”

Missing resources. The teachers are not provided with everything they need because the curriculum only addresses core instruction. This means teachers are on their own when deciding on how to address remediation needs. Coach Jaime said many conversations with teachers are to “talk about MTSS plans.” This could mean teachers are not sure how to address individual students’ needs. According to the school leaders, during previous school years, the district provided a digital resource to support intervention/extension plans. However, teachers no longer have access which has led some teachers at LES to write grants to access online programs. This has resulted in teachers getting access for the entire school. Coach Jamie said, "we had a couple of teachers last year that were part of a pilot where they granted us (the school) access to Freckle (an online platform that provides fluency practice) without having to pay the fee that I know it costs.” According to the leadership team, many teachers use digital resources to support their MTSS plans. However, teachers will not have to look for their own resources for much longer because the district recently purchased supplemental resources for mathematics. According to Principal Alex, “teacher-made resources” and materials found on “Teachers-Pay-Teachers will no longer cut it” because new laws are changing how students qualify for EC services. With that said, implementation of the program will be a requirement.

The Case of Madison Elementary

Background

Madison Elementary School (MES) serves 630 K-4 students in a rural location within the district. K-2 classroom teachers are responsible for teaching all subjects, while 3-4 teachers are departmentalized. The leadership team includes the principal, assistant principal (AP), a teaching and learning coach, and an MTSS coach. For this study, the principal (Principal Carson), the teaching and learning coach (Coach Jordan), and the MTSS coach (Coach Lane) were interviewed. It is important to note that MES is one of four schools in the district with a Restart Status. According to state law, recurring low-performing schools apply for Restart Status which provides schools with the same exceptions as charter schools. This means the school is not bound to some district policies. This information is relevant because it allowed modifications to the district calendar to include more time for PD than other schools in the district, and teachers have more flexibility around instruction.

Principal's Expectations

Principal Carson started at MES three years ago and is working with her team to strengthen core instruction by developing a shared understanding of grade-level standards. She explained, "We are trying to build our core instruction so that we have consistency from classroom to classroom." Principal Carson said, "Everybody wants to put their own spin on how they teach a lesson and that's possible. But then there has to be that core that they are teaching in alignment with one another." She explained that the leadership team communicates often on how to meet the learning needs of the teachers. She said, "It's with the whole admin team at least once a week." They talk about what they have noticed during walk throughs. She said, "It is a chance for us to collaborate and talk about what needs to happen and how can we make that happen. And then we implement the play. I guess I'm thinking more so on a sports term thing. We implement a play. And that's what it's all about. It's like our huddle." The weekly meetings also provide time to brainstorming ideas on the best way to approach certain situations like having a difficult conversation with a teacher.

Expectations. Principal Carson is present; however, she lets the coaches and teachers take the lead as she believes her role is to empower teachers to make their own decisions. She recognizes teachers as the school's greatest strength and believes teachers will improve their core instruction by following “common pacing and through working with coaches.” The high level of autonomy provides teachers freedom with instructional decisions.

Teacher autonomy. The Restart Status allows MES teachers flexibility when choosing instructional resources. The flexibility aligns with the school’s vision found in the school improvement plan. It states, “Compassionate and competent school innovators will engage each student in relevant and personalized learning experiences in preparation for careers, college, and life.” Coach Jordan explained that having this freedom “does not mean teachers can do whatever they want” because grade-level Standards still need to guide instruction. Similarly, Principal Carson said, “They don’t have a free for all.” She added that teachers use Standards to determine what to teach. However, teachers do have the liberty to choose their instructional methods. For example, many teachers incorporated project-based learning (PBL) into their 2018/19 mathematics instruction. Principal Carson said PBL allows teachers and students to “have fun, learn, and actually have some real-life application.” She remembers one class created a pizza parlor, and another planned a holiday party. Coach Lane agrees that teachers put a lot into PBL with “creative ideas to engage (students).”

In addition to choosing how to teach, third and fourth-grade teachers also make decisions on grade-level organization. During the 2018/19 school year, both grade-levels departmentalized. This means two teachers worked together with one teacher responsible for mathematics and science instruction, and the other teacher was responsible for teaching ELA and social studies. Additionally, the grade-level partners flex-grouped students between the two classes. For example, the mathematics teacher taught the students that were seen as advanced during one class period, and the students recognized to need extra support during the other class period. Coach Jordan explained that the fourth-grade teachers continued to group this way except “One 4th grade teacher teaches all subjects, no switching, since there is an odd number of classes.” However, the third-grade team decided to group homeroom classes by perceived ability so they would not have to flex-group students between partner teachers. Coach Jordan said, “Basically, students are ability grouped.” According to Principal Carson, allowing teachers with this flexibility enables them to meet all the needs of their students.

Embedded Learning through Coaching

Coaching role. According to their titles, Coach Jordan supports teachers with all content and Coach Lane helps teachers with MTSS. However, their actual roles are not so limited. According to Principal Carson, one way in which the coaches at MES support teachers is by going “into the classrooms to help. It can be (to support) classroom management or maybe just with one student.” The coaches are also responsible for “Making sure that teachers have an understanding of the curriculum, what it is that they should be teaching and how to go about teaching it.” These expectations support the data from phase 1 of this study. Specifically, this type of coaching takes time which might mean the coaches work intensely with few teachers. This would explain why the school had a low coaching frequency mean but a high activity mean. In other words, teachers’ interactions with coaches are less frequent, but when they do interact with a coach, they are engaging in activities that represent all WHWy categories.

The lower frequency score (EMF) could also be explained by the amount of time coaches have to meet with teachers. Sometimes, the coaches fill in for classroom teachers. Coach Jordan explained that this is one of the challenges of being in a rural area. She said, “It’s hard to get highly qualified people." Last year she was "covering a kindergarten classroom for three months." She laughed and said, "The typical day just kind of varies based on what's happening in the building." Taking over a classroom seems to be normal for the coaches at MES. At the time of the interview, Coach Lane was preparing to take the position of a third-grade teacher. She explained that she wanted to do it because the students need a teacher. For this reason, it could be assumed that the coaches at MES are not able to support teacher learning in the same way as a full-time coach working at a different school.

Coaching Style. Principal Carson said, "We have all been through Cognitive Coaching (training) so that really helps when are working with teachers to find out what it is that they need." Coach Jordan said that the goal of this type of coaching was to " have teachers become directive thinkers." This means teachers would not need so much guidance. She tries to develop teachers by asking reflective questions like, "What do you notice?" She added that this type of coaching works better than just telling people what to do because it helps them take ownership of their decisions. She said, "If someone's telling you to do something, you'll do those things, but you're not going to own it." However, she continued, "Coming up with your own things you're going to own it and be more apt to do it."

Teacher Needs. When thinking about which teachers in the school need the most support with mathematics instruction, Principal Carson said, "a lot of times our veteran teachers struggle because things have changed." This group of teachers will say things like "It's not the way it used to be" and "This is not how I used to teach it." However, she is quick to acknowledge teachers' strengths. She said, "They just give themselves immensely to the students, to planning, and to making sure students are getting it." Coach Jordan was more specific when she talked about the support needed. She said that there needs to be more "rich experiences in our classrooms” that develop students' conceptual understanding. She added, “Our kids don't have that strong number sense and then they get to third grade and don't have a strong (understanding of) place value.” Coach Lane expressed a similar opinion when she said, "teachers wanted to skip concrete activities and jump right to the algorithms." She has noticed that lessons include “a lot of computation practice.” However, they also recognize that changing instruction is a process that is difficult because as Coach Lane put it coaching has to be done in way that “doesn't crush morale.”

Embedded Learning during PLC Meetings

Expectations. The coaches support teachers during PLC and grade-level planning meeting. The autonomous nature of the school allowed teachers to decide which subject area would be the focus during the 2018/19 PLC meetings. Coach Jordan explained that teachers chose “to work on our standards-based teaching and learning through the lens of mathematics.” She expressed how happy she was with the choice to focus on mathematics calling it “awesome!" Coach Jordan remembered that when they started the conversations around Standards lacked depth. Coach Lane agreed and explained that typically discussions about Standards consisted of teachers sharing activities they use to teach but never a plan on how to teach. She said, “trying to change that culture (and make it) okay if you don't agree with somebody” is difficult. She said that teachers are “not comfortable yet because they've never had the opportunity to practice.” She said that Principal Carson is good at supporting this change and will support teachers to share by saying things like “it’s okay say it” and then “praising as much as possible.”

Strategy. This year the coaches continue to use a combination of district-provided materials and state documents to guide the PLC meetings. Coach Jordan explained that "unpacking standards (helps teachers) to have a better understanding of [Standard-based] grading." This work has not gotten easier. Coach Jamie said, "This year we've kind of given teachers a little bit more flexibility as far as trying to let them plan during PLC and we're not being successful." She explains it as a "double-edged sword". "They don't want you to control what they're doing. But when you give them the freedom, they can't function on some level." This might mean that teachers are not yet comfortable leading conversations around mathematics. Coach Lane added, "When we're in PLC meetings, they look to us to lead." She wonders if teachers "really value the time that they are in here [PLC meetings]." The coaches are doing a gradual release and continue to support teachers by providing agendas and reminding them to refer to the standards. Just recently the grade-level teams worked together to create formative assessments, which will be used to lead discussions in upcoming meetings. Coach Jordan thinks that analyzing student work might lead to "those aha moments." The coaches hope to develop PLCs that can function on their own.

Both coaches agree that after a year of digging into the meaning of the mathematics Standards, teaching is not yet where it needs to be. Coach Lane said, "I still don't feel like there's that solid definition of core." She wonders why some teachers do not just try the methods that she suggests like using manipulatives. She said, "Quite honestly I don't know if it's a comfort thing or they don't see the point of giving them counting bears." Coach Jordan thinks it is because "teachers really don't understand the depth that is needed for students to understand." Although they have not seen a significant change in instruction, the school's mathematics scores show gains, and teachers enjoy teaching mathematics.

Vertical PLCs. The Restart Status provides four additional days for embedded PD. Last year, teachers were able to discuss mathematics with teachers working at nearby schools.

According to Principal Carson, the PD occurs at least twice a year. “We come together, and our teachers have some type of instructional development for their content area. And then they have time to have vertical alignment conversations. For instance, the middle school (teachers) will tell fifth-grade (teachers) what students need for sixth grade.” These extra meeting days could explain the high PLC frequency score determined during phase 1.

Provided Resources

Collection of resources. Teachers at MES are not limited on what they use to guide their instruction. However, they do have access to several resources. One is a subscription to an online mathematics website that focuses on differentiation. Coach Jamie said, “I don't know how all of the grade levels are using it.” Coach Lane explained that some teachers incorporate it during “center rotations where students play for 15-20 minutes.” The other available resource is a collection of material gathered by the school mathematics team. Coach Jordan said the mathematics team includes “a teacher for every grade level and the coaches.” According to Principal Carson, the team has put together resources that include things like a “pacing guide” and ideas about “different types of (teaching) strategies.” The team meets often to gather resources and ideas that all teachers can access. It could be assumed that the teachers serving on the mathematics team have more opportunities to discuss mathematics instruction. This might explain some of the variation in the scores determined in phase 1 of this study.

Coach Jordan expressed some concerns with the teacher-developed pacing guides. She said, "I think it can be a weakness as well. Because you have people creating a curriculum that, you know they're in the trenches, but they may not have the understanding of what should come before a concept to really build on." Coach Lane agrees and wonders why Restart Status provides more liberties. She knows that teachers love having the freedom to make instructional decisions, but she questions if this makes sense. She said, “59% of our third-graders test below the 40th percentile in algebraic operations.” She questioned, “Shouldn’t it be a bit more structured?” What she is suggesting is that the Restart policy should be reconsidered because it would make more sense to help schools develop a structure that works instead of just letting them try whatever they want and hope it works. In contrast, maybe it is working. According to Coach Jordan, there was a “10-point increase in proficiency.” Or perhaps maybe high stakes assessments do not provide the right information to determine success.

Required resource. Teacher autonomy will soon decrease due to the 2020 discrepancy laws. Coach Lane explained that MTSS uses student data to recommend testing for potential EC services. However, the new laws “kind of put pressure on your MTSS paperwork” because they will be used to qualify students for services instead of “a School Psychologist coming in and evaluating them.” She described this change as “a little bit scary” but believes that after working out the kinks it will be “in the best interest for students.” The change in the MTSS process will require all of the interventions to be research-based. She pointed to some boxes on the other side of the room and said the district provided us with an intervention program but “nobody has been trained on it.” Principal Carson also spoke of the new program and said teachers are looking forward to having it.

Between Cases

Both principals seem to be trying to reach a similar goal and are both using district initiatives to guide some decisions. For example, the school improvement plan for both schools state goals that focus on student learning. One goal listed in LES’s school improvement plan is to “develop standards-aligned units of study in order to personalize instruction for each student in each grade and subject” and the MES goal is to “incorporating the strengths, challenges, preferences, interests, and needs of adult and student learners to improve learning outcomes for the school community.” Moreover, both schools used the standards-based grading initiative to lead PLC work, and all of the school leaders attended cognitive coaching training. Although there are some similarities, the differences between the leadership styles seem to be more obvious.

As other studies have suggested, the leadership style may influence embedded learning because the principal establishes the school’s learning culture (Mitchell & Castle, 2005). In this study, Principal Alex is trying to shift the school’s culture to be more collaborative. He leads by modeling what is expected as he spends a lot of time collaborating with others at the school. His plan is specific yet not rigid. In other words, his approach to meeting his goal is planned but allows for flexibility. This was demonstrated when he talked about changing his expectation for PLC meetings after observing that teachers did not yet feel comfortable to have the types of conversations he planned. He also made changes to teacher teams which he described as “getting people on the right seat on the bus.” Although there was pushback, Principal Alex reported, “there's the right leader on each team” and he thinks that teachers now understand his decisions. This finding is similar to other research that suggests the personalities of teachers can determine the effectiveness of a PLC (Nickerson & Moriarty, 2015).

In contrast, Principal Carson is committed to empower teachers, and she does this by giving them the freedom to choose what they teach and learn. She explained that there were differences in how PLCs engaged. For example, “fourth grade is very intentional and meticulous with planning.” Although there was not enough information to determine why the teams varied, other research suggests that experienced teachers focus more on student learning than novice teachers (Horn & Kane, 2015). This might be something for Principal Carson to consider when creating grade level teams. Principal Carson took on an observer role during PLC meetings. She attended to “answer questions and help direct if I needed,” but the coaches were responsible for facilitating conversation around the teacher-chosen subject. Teacher decisions were also used to determine how students were sorted into classrooms for instruction. This type of leadership feels more liberal than the leadership style employed by Principal Alex. However, one type of leadership style does not appear to be more effective at shifting teachers’ instruction. Other research has linked principal support and improved mathematics instruction (Heck, Banilower, Weiss & Rosenburg, 2008). In comparison, the findings in this study suggest that supportive principals need time to develop teachers’ instruction. The rest of this chapter discusses principals’ decisions that impact embedded learning and also provides some reasons why instructional shifts might be slow.

PLC Meetings and Coaching Opportunities

The findings in this study suggest that many teachers have a planning period built into their daily schedules, which aligns with what others have found (NCES, 2012). The schools in this study scheduled time for teachers to collaborate during weekly PLC meetings. However, the interviews revealed that teachers engage in mathematics-focused PLCs less than reading-focused PLCs. Coach Jamie thinks the district and even the state sends a non-verbal message that reading instruction should be the priority. The state initiative for all students to meet a specific reading level by the end of third grade “communicates, very strongly, that reading gets more emphasis.” In contrast, the principals provided a different explanation. Principal Alex explained that because teachers were not provided with a reading curriculum, PLC time was needed to “create materials and write lessons and assessments.” Whereas Principal Carson explained that more PLC time is typically focused on reading due to “the need in the area of reading” determined by the end-of-grade assessment data. Regardless of the reason, PLCs do spend more time focused on reading. This could be one reason the shifts in how mathematics is taught seem slow. That is teachers may perceive that reading instruction is considered a priority because the schedule includes more time for it. It could be that school leaders believe reading instruction is a priority. If that is the case, the district should consider providing school leaders with PD so that there is a common understanding of their responsibility to support the implementation of the mathematics standards. There might also be a need for school leaders to learn scheduling strategies so that teachers have adequate time to discuss all subjects they are responsible for teaching.

The leaders at both schools acknowledged that teachers might not have experiences learning mathematics in the way they are expected to teach it. They address this concern by supporting teachers with instructional coaching. The leaders both talked about cognitive coaching; however, it seemed to be more prominent at LES due to how often it was referenced by the three school leaders. Regardless, the schools have similar coaching goals described by Coach Jamie as the teachers "taking ownership" and by Coach Jordan as getting teachers to be "more directed thinkers." This means coaching is focused on developing teachers to think deeply about issues and solutions. However, this type of coaching might not be addressing the needs of the teachers. This is based on the perception that teachers do not yet have the knowledge needed to provide Standards-based instruction which seemed to be shared by the all three leaders at LES as well as the coaches at MES. For this reason, it seems unreasonable to think that cognitive coaching will support teachers to develop the specialized knowledge needed to teach mathematics. The district could improve coaching by using content and cognitive coaching together. This means the type of situation would determine the style of coaching used. Although national data has been used to determine that many elementary teachers have access to coaching (NSSME, 2018), this study provides evidence that coaching experiences are likely to vary from school to school.

The style of coaching may also help explain the data collected during phase 1 that suggested teachers at LES had more frequent coaching experiences but did not engage in any WHWy activities. In other words, coaches had time to engage with teachers, but the activities were guided by the teacher. In contrast, data from phase 1 showed MES teachers had less frequent coaching opportunities, but the coaching they did receive tended to incorporate activities from all five WHWy categories. Although the reason is not explained by the interview data, it could be that MES coaches engaged teachers in WHWy activities, but their added duties (e.g., filling in the classroom) limited the time the coaches spent with teachers. This points to the need for the restart status to be reconsidered. It seems like providing extra money to recruit teachers might be a better way to support high need schools.

Challenges

Leaders at both schools explained that teachers' lack of confidence and content knowledge made it difficult to facilitate meaningful conversations around mathematics. This supports the claim that teaching mathematics requires specialized knowledge and skills (Ball, Thames, & Phelps, 2008). Moreover, this provides evidence that it takes time to develop effective PLCs. As the school leaders pointed out, collaborative PLCs were something they were working towards. Principal Alex described this process as a journey that started with creating a "safe environment" for teachers to share. He admitted that PLCs are just beginning to analyze formative assessments because "teachers cannot analyze students' work without understanding the expectations." According to Coach Jordan, MES has experienced a similar situation, and teachers are “just beginning” to see the role formative assessment has in planning. For that reason, low PLC activity scores might not indicate an area of need. Instead, it might be an area that is in the process of improving. If this is the case, it is likely that PLC activity scores for teachers working at these two school would increase over time.

Teachers are doing the job they have been prepared to do, and perhaps the need for more intensive training is the reason teachers are not engaging in meaningful conversations focused on student understanding. The district-provided PD focused on Investigations demonstrates that teachers have had inadequate PD opportunities because training was offered to only select teachers each year. In other words, some teachers were offered PD after they already figured out how to implement the curriculum on their own. The district expectation is also unclear and is interpreted differently by the principals. Principal Carson said they stopped using Investigation because the teachers did not like it. However, she and her teachers looked forward to the district providing a curriculum next year. She said it would help align instruction because, “if you have that mathematics curriculum, they will all be teaching the same thing.” This comment points to the need for PD that will help principals understand the mathematics standards. Principal Alex also confirmed this need when he said he never received any curriculum training. He has chosen to immerse himself in the curriculum because he thinks it is important to understand what the teachers need to know, but this choice has been self-directed, not through a formal training. He said, “I walked into an elementary school. I didn't know, other than we had a curriculum, like any of the components. And still to this day, having been principal for two-plus years, I never had training.”

Slow Change

School leaders seem happy with the slow changes at their schools and seem to believe that training will start to change instruction. However, misalignment of initiatives might also be a reason why instruction is not changing. Teachers may ignore what is being pushed at them because the initiatives change every year. This means teachers may not think a current initiative is worth putting time into because initiatives change every year. Coach Jamie said the focus at LES used to be “individualized learning,” but the district moved away from that. In the same way Principal Carson said, “Last year we really focused on having students engage in project-based learning. So, I think that was really a strength that I saw in mathematics.” However, she reported that “not as much” PBL has been happening this school year.

Like other research implies, teachers might also be apprehensive to change instruction because of the emphasis put on testing (McGee, Polly, & Wang, 2013). Coach Jamie said, “They (teachers) are very worried about that end-of-grade test that their kids have to take at the end of the year and how that measures them as a teacher.” Likewise, Coach Jordan said, “I think there's always pressure from testing in general... and that need to just get kids to be able to do it well.” This may be why Principal Alex has noticed that “seasoned successful teachers” are very hesitant. Although there is no data to confirm this, it is likely teachers with high percentages of students passing end-of-grade test are probably less likely to risks with their instruction.

To conclude, the findings of this study suggest that teachers participate in embedded PD focused on mathematics instruction, and the leadership style and decisions made by schools’ principals impact these experiences. However, principals do not control all of the factors that influence embedded PD. In this study, the district’s grading initiative guided the focus of PLC meetings at both schools. Although the school leaders in this study used the initiative to guide conversations that seemed to promote teacher learning and understanding, this might not be the case in all of the district's elementary schools. Further research should investigate more of the schools. The location of the school was also found to influence embedded PD at MES. Coach Jordan explained that the rural area of the school limits the number of qualified applicants, which led to both her and Coach Lane filling in for classroom teachers. These findings suggest that multiple factors influence embedded PD. This information should be considered by all school leaders and policy writers when making decisions about mathematics-focused PD or interpreting school and district data.

Chapter 6: DISCUSSION

With this study, I examined the mathematics-focused PD opportunities of teachers working in the same school district. Through survey data collected from teachers working in all 23 of the district's elementary schools and information obtained through interviews with school leaders at two of the schools, I determined that teachers have varying opportunities to engage in mathematics focused PD. Moreover, there are differences between the frequency of PD and the activities that teachers engage in during PD. Some of the differences can be explained by the school context. This chapter will first present the limitations followed by the key findings and accompanying implications.

Limitations

There are two limitations in this study that could be addressed in future research. First, the results may not be generalizable because the study focused on only one school district. Moreover, some teachers in the district did not participate. Therefore, the data was collected from teachers who chose to participate in mathematics education research. Teachers that did not participate could have different views of their PD experiences. Second, the qualitative data was collected from a limited sample, particularly from schools with high SCS scores. In these schools, the school leaders seemed to value mathematics instruction. However, this might not be the case for all schools in the district. Further research would need to be conducted in order to make any claim about the effect school context might have on teachers' learning opportunities.

Key Findings

Embedded PD

The results of this study suggest that teachers participate in three types of PD which include embedded PD, external PD, and self-directed PD. According to the data collected from teachers and school leaders, embedded PD can occur during planning periods, PLC meetings, and coaching opportunities. Data from both sources indicated that more teachers regularly attending grade-level PLCs compared to vertical PLCs. This does not seem surprising that schools only incorporate grade-level PLCs due to the likeliness of an already filled daily schedule. However, it is not clear why some teachers met with vertical PLCs while others did not.

The findings also show that there are differences between what occurred during PLC meetings. Some teachers reported engaging in activities from all five of the WHWy categories and other teachers reported engaging in no WHWy activities. More interestingly, schools seem to lack coherence because teachers in the same school did not report the same activities. As other research has shown, maybe the difference is due to personality differences between PLC members (Nickerson & Moriarty, 2015), or perhaps more experienced teachers lead more productive PLCs (Horn & Kane, 2015). It is also possible that other schools are in the process of developing effective PLC such as the school leaders at LES and MES. It may take longer than expected because teachers might be uncomfortable engaging in conversations around mathematics (Battey & Franke, 2008). Regardless of the reason, the findings suggest the need for PD focused on establishing effective PLCs. The district may want to consider this investment rather than spending money on more instructional resources.

Like previous research, the findings in this study show that coaching opportunities vary from school to school (Mudzimiri, Burroughs, Luebeck, Sutton & Yopp, 2014) with most teacher/coach interactions being informal and few that include WHWy activities. This can be explained by the different ways in which coaches are utilized. Or perhaps, coaches are not trained or expected to provide mathematics support. Including teacher interviews in future research might provide information to better explain the coaching opportunities.

External PD

Like previous research, the finding in this study suggest that some teachers have opportunities to participate in external PD that is focused on resources provided by the school (Collopy, 2003; McGee, Polly, & Wang, 2013; Stickles, 2011). The data collected from the teachers did not explain which teachers were given opportunities. However, the interview data did provide a possible explanation. AP Lee said that teachers were chosen to attend district curriculum training if they were struggling to implement the resource or had never attended. Considering that the TLO-M only asked about PD opportunities during the 2018/19 school year, it was not surprising that only some teachers indicated participating in lesson plan resource PD. However, from information provided by the school leaders at LES, it is likely that many teachers have attended the PD during previous years. That is because the district has provided training each year since the curriculum was purchased five years ago. This method of providing training to some teachers each year seems inadequate because by the time some teachers receive training, they have already been using the curriculum for years. Kennedy (2017) would say that these teachers have already figured out how to implement the curriculum on their own so the information from PD might not transfer into practice. It might be better for the district to provide all teachers training on provided resources before they start using the resources. Therefore, teachers will receive the same message and be able to support each other when using the resource.

Like other research has shown, teachers also participate in external PD that is mathematics-focused but not focused on a specific resource (Bailey, 2013; Gee &Whaley,

2016). The external PD experiences varied in duration with some teachers participating in over twenty hours which has been suggested as the duration needed to be effective (Desimone, 2009). However, like other studies have reported, it may be possible that PD with less duration can be effective (Carpenter & Linton, 2016; Forte, Humphreys, & Park, 2012). In this research, the school leaders at LES considered one afternoon of PD very powerful. Like other research has shown, the session confronted teachers about their mathematics instruction while engaging them in a problem-solving lesson (Zwiep & Benken, 2013). In fact, Principal Alex said the experience influenced one teacher to learn more about the purpose of the curriculum which changed her instruction. The leadership team at LES participated in the PD with the staff which seems to exemplify their mission of developing a collaborative learning environment and can explain why LES had a high SCS score (e.g., all teachers attended PD). The teacher data showed differences between the activities they participated in during other external PD opportunities. However, interviews with the school leaders did not provide any additional information that might explain the variations. Further research could investigate these experiences through teacher interviews.

Self-Directed PD

The findings from this study show that teachers engage in self-directed PD during and after work hours. This might be a necessity due to the fact that teachers are not provided with a resource to guide their MTSS plans. Coach Jamie acknowledged that “teachers are pulling from what they know and what they can find to do any sort of intervention above and beyond what's offered through the curriculum.” This means that in addition to all their other responsibilities teachers are required to find materials for instruction they are required by law to provide. According to Principal Alex, teachers supplemented during regular lessons with resources that did not align with grade-level standards. Therefore, it is likely that choosing supplemental material for standards that are addressed before their respective grade level is particularly difficult. Not providing teachers with these resources seems irresponsible. As leaders from both schools mentioned, teachers will be provided with a resource soon. However, without proper training and time to practice, it is likely that lessons will not be taught as intended. This is because as shown in other research, teachers perceive resources differently due to factors such as their beliefs about teaching mathematics and their content knowledge (Sherin & Drake, 2009). Further research would help determine other reasons why teachers engage in self-directed learning.

School Context

The majority of teachers in this study indicated that they were provided with a daily planning period and also indicated that PLC meetings took place during school hours. This was confirmed by the interviews with the school leaders. Yet it was not determined if this was a district policy or a school-level decision. Other decisions were clearly school level. One example is the use of the provided textbook. The school leaders at LES seemed to love the Investigations textbook while school leaders at MES chose not to use the curriculum when given restart status. Although the school leaders seemed to be clear on the resources provided to teachers, the teacher data did not indicate that teachers perceived the information the same way. For instance, some teachers at LES said the school provided certain resources (e.g., lesson plans, pacing guide) while other teachers at LES said they were not provided with the resource. Likewise, there was also conflicting responses from the MES teachers. Due to the fact that all the schools in the district are working towards the same goals, it seems that communication of goals and available resources has not occurred with all teachers. This might mean there needs to be more clarity as to the expectations and a reevaluation of how communication occurs (i.e., through which means).

Conclusion

The findings in this study show that teachers engage in PD that is focused on mathematics. While this is not surprising, the study adds important information about the variation in the frequency and nature of teachers' opportunities to engage in embedded, external, and self-directed learning. The data suggests that teachers likely do not receive adequate PD due to the school leaders' comments about teachers' confidence in teaching mathematics, content understanding, and observation of teachers using traditional teaching methods. There is also evidence that school leaders might have not been provided enough training on the difference between previous and new standards. For these reasons, it seems unfair to hold teachers and schools accountable for student achievement. The results of this study suggest that policy and district leaders might not fully understand the complexity of teaching elementary mathematics. Therefore, researchers should work on making all stakeholders aware the time and PD needed to become skilled at instruction before using student achievement to determine the effectiveness of instruction.

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APPENDICES

Appendix A: Recruitment E-mail for Cognitive Interview Participants

Dear XXXXX,
I am Amanda Kates, a doctoral student at NC State University in the Department of Teacher Education & Learning Sciences. I am writing to invite you to participate in an interview about a survey that I recently developed. The survey asks questions about the opportunities you were provided to learn about mathematics content and instructional strategies during the 2018-19 school year. During the interview, you will take the survey and talk out loud about your thinking. The purpose of the interview is to understand how teachers interpret the items to ensure that the survey collects valid information. Your expertise and knowledge as a teacher in grades K-5 is valued and needed for this study. Ultimately, the goal is that the survey will help guide decisions made by districts and schools about professional development for teachers.

You are eligible for this study because you taught mathematics in grades K-5 in a regular classroom setting during the 2018/19 school year in a United States school. (Note: Teachers who taught in [redacted] are not eligible.) If you participate in the study, you will receive a $40 gift card from either Amazon or Target. This gift card is a small token of my appreciation for your contribution to making the survey of the highest quality.

Thank you for considering this invitation, and I look forward to hearing from you.

Sincerely,
Amanda Kates

Appendix B: Adult Informed Consent Form for Cognitive Interview Participants

Title of Study: Validation of a Survey Measuring Elementary Teachers' Learning Opportunities in Mathematics (16852)
Principal Investigator: Amanda Kates, ajgosek@ncsu.edu, 914-330-9935
Faculty Point of Contact: Temple Walkowiak, tawalkow@ncsu.edu, 919-513-0918

What are some general things you should know about research studies?
You are invited to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate, and to stop participating at any time without penalty. The purpose of this research study is to understand the opportunities elementary teachers have to learn about the mathematics they teach. We will do this through asking you to participate in a cognitive interview while completing an online survey.

You are not guaranteed any personal benefits from being in this study. Research studies also may pose risks to those who participate. You may want to participate in this research because you want to share about your learning experiences as a teacher of mathematics. You may not want to participate in this research because your time is limited.

Specific details about the research in which you are invited to participate are contained below. If you do not understand something in this form, please ask the researcher for clarification or more information. An electronic copy of this consent form will be provided to you. If, at any time, you have questions about your participation in this research, do not hesitate to contact the researcher(s) named above or the NC State IRB office. The IRB office's contact information is listed in the *What if you have questions about your rights as a research participant?* section of this form.

What is the purpose of this study?
The purpose of the study is to ensure that valid information is collected with the Teachers' Learning Opportunities in Mathematics Survey (TLO-M).

Am I eligible to be a participant in this study?
There will be 5-7 participants who complete the cognitive interview and survey.
There will be 100-120 participants who complete the survey.

In order to be a participant in this study you must have been a classroom teacher that taught mathematics to elementary students in a school located in the United States during the 2018/19 school year.

You cannot participate in this study if you were employed as a special education teacher during the 2018/19 school year.

You cannot participate in this study if you were employed by [redacted] during the 2018/19 school year.

What will happen if you take part in the study?

If you agree to participate in this study, you will be asked to do all of the following:

1. Complete an online survey about your opportunities to learn about the mathematics you teach during the 2018/19 school year.
2. Think aloud as you complete the survey and respond to follow-up questions about your interpretation of the survey items.

The total amount of time that you will be participating in this study is between 45 and 60 minutes.

Recording and images

If you want to participate in this research, you must agree to be audio recorded. If you do not agree to be audio recorded, you cannot participate in this research.

Risks and benefits

There are minimal risks associated with participation in this research. A benefit is having the opportunity to identify and reflect on your own learning opportunities as an elementary teacher of mathematics. The indirect benefit is your contribution to the development of a survey instrument that can potentially inform decisions regarding professional learning opportunities for teachers.

Right to withdraw your participation

You can stop participating in this study at any time for any reason. In order to stop your participation, please tell the interviewer that you would like to stop. If you choose to withdraw your consent and to stop participating in this research, your responses to the survey and interview will not be used.

Confidentiality, personal privacy, and data management

Trust is the foundation of the participant/researcher relationship. Much of that principle of trust is tied to keeping your information private and in the manner that we have described to you in this form. The information that you share with us will be held in confidence to the fullest extent allowed by law. Protecting your privacy as related to this research is of utmost importance to us. How we manage, protect, and share your data are the principal ways that we protect your personal privacy.

Data generated about you in this study will be de-identified.

De-identified. De-identified data is information that at one time could directly identify you, but that we have recorded this data so that your identity is separated from the data. We will have a master list with your code and real name that we can use to link to your data. While we might be able to link your identity to your data at earlier stages in the research, when the research concludes, there will be no way your real identity will be linked to the data we publish.

Data that will be shared with others about you will be anonymous.

To help maximize the benefits of your participation in this project, by further contributing to science and our community, your anonymous survey responses only will be stored for future research and may be shared with other people without additional consent from you.

Compensation

For your participation in this study, you will receive a $40 electronic gift card from Amazon or Target.

If you withdraw from the study prior to its completion, you will not be compensated.

What if you have questions about this study?

If you have questions at any time about the study itself or the procedures implemented in this study, you may contact the researcher, Amanda Kates by email ajgosek@ncsu.edu, or by phone 914-330-9935. You many also contact her faculty advisor, Temple Walkowiak by email tawalkow@ncsu.edu, or by phone 919-513-0918.

What if you have questions about your rights as a research participant?

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact the NC State IRB (Institutional Review Board) Office. An IRB office helps participants if they have any issues regarding research activities. You can contact the NC State IRB Office via email at irb-director@ncsu.edu or via phone at (919) 515-8754.

Consent To Participate

By clicking the link below, I am affirming that I have read and understand the above information. All of the questions that I had about this research have been answered. I have chosen to participate in this study with the understanding that I may stop participating at any time without penalty or loss of benefits to which I am otherwise entitled. I am aware that I may revoke my consent at any time.

Appendix C: Interview Protocol (Cognitive Interview Participants)

Thank you for participating in this interview as you complete the survey. I will ask that you read the questions aloud as you take the survey and say your responses out loud. You do not need to elaborate on your responses to the survey when you are sure of your response. However, if you're unsure what an item means, please describe why you are unsure because this will help me make the survey better. Also, if you're not sure how to respond to the item because you can't decide if it happened or not for you, please describe why you are uncertain.

At the conclusion of the survey, I am going to ask you about some of the sections that you did not complete because the survey skips over sections based upon how you respond. But, I want to utilize your expertise for how I can make those sections better, too.

There are no right or wrong answers on the survey or during this interview, and I appreciate your help in making my survey better.

I would like to audio record this interview so I can focus on what you are saying and so that I can analyze your responses later to make the survey better. Is this okay with you? If at any point, you want me to stop the audio recorder, please let me know. START AUDIO RECORDER.

This is Amanda Kates with INTERVIEW ALPHANUMERIC ID on DATE.

Participant will read questions aloud. If the participant is unsure about an item, the interviewer will probe with questions like:

- *Why is this confusing for you?*
- *What language do you use at your school to describe this type of PD experience?*
- *Tell me more about which part of the item is unclear.*

At the conclusion of the interview, the interviewer will ask the participant to look at the items that were skipped due to "skip logic" on Qualtrics based upon how participant answered.

- *For this item, is there any part that is confusing for you?*
- *Why is that confusing?*
- *Do you think this item could be interpreted differently at different schools or in different districts?*

Appendix D: Recruitment Blurb for Social Media – Survey Participants

Did you teach mathematics in grades K-5 in a regular classroom setting during the 2018-19 school year in the United States*? Please consider completing this brief survey about your opportunities for professional development and learning. The survey is anonymous and will take approximately 5-15 minutes of your time. At the end of the survey, you will have the opportunity to enter your name in a raffle for a Target or Amazon (your choice). Twenty $15 gift cards will be given away! (*Note: 2018-19 teachers from [redacted] are not eligible.)

Appendix E: Adult Informed Consent Form for Survey Participants

Title of Study: Validation of a Survey Measuring Elementary Teachers' Learning Opportunities in Mathematics (16852)
Principal Investigator: Amanda Kates, ajgosek@ncsu.edu, 914-330-9935
Faculty Point of Contact: Temple Walkowiak, tawalkow@ncsu.edu, 919-513-0918

What are some general things you should know about research studies?
You are invited to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate, and to stop participating at any time without penalty. The purpose of this research study is to gain a better understanding of the opportunities elementary teachers have to learn about the mathematics they teach. We will do this through asking you to participate in an online survey.

You are not guaranteed any personal benefits from being in this study. Research studies also may pose risks to those who participate. You may want to participate in this research because you want to share about your learning experiences as a teacher of mathematics. You may not want to participate in this research because you are not guaranteed financial compensation.

Specific details about the research in which you are invited to participate are contained below. If you do not understand something in this form, please ask the researcher for clarification or more information. A copy of this consent form will be provided to you via an electronic download. If, at any time, you have questions about your participation in this research, do not hesitate to contact the researcher(s) named above or the NC State IRB office. The IRB office's contact information is listed in the *What if you have questions about your rights as a research participant?* section of this form.

What is the purpose of this study?
The purpose of the study is to ensure that valid information is collected with the Teachers' Learning Opportunities in Mathematics Survey (TLO-M).

Am I eligible to be a participant in this study?
There will be 100-120 participants in this study who complete the survey.

In order to be a participant in this study you must have been a regular classroom teacher that taught mathematics to elementary students in a school located in the United States during the 2018/19 school year.

You cannot participate in this study if you were employed as a special education teacher during the 2018/19 school year.

You cannot participate in this study if you were employed by [redacted]) during the 2018/19 school year.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to do all of the following:

1. Complete an online survey about your opportunities to learn about the mathematics you teach during the 2018/19 school year.

The total amount of time that you will be participating in this study is between 5 and 15 minutes.

Risks and benefits
There are minimal risks associated with participation in this research. A benefit is having the opportunity to identify and reflect on your own learning opportunities as an elementary teacher of mathematics. The indirect benefit is your contribution to the development of a survey instrument that can potentially inform decisions regarding professional learning opportunities for teachers.

Right to withdraw your participation
You can stop participating in this study at any time for any reason. In order to stop your participation, please stop answering the survey questions. If you choose to withdraw your consent and to stop participating in this research, your responses to the survey questions that you answer will be deleted when the data is downloaded.

Confidentiality, personal privacy, and data management
Trust is the foundation of the participant/researcher relationship. Much of that principle of trust is tied to keeping your information private and in the manner that we have described to you in this form. The information that you share with us will be held in confidence to the fullest extent allowed by law. Protecting your privacy as related to this research is of utmost importance to us. How we manage, protect, and share your data are the principal ways that we protect your personal privacy.

If you do not enter your name into the raffle (see *Compensation* section), data generated about you in this study will be anonymous.

Anonymous. Anonymous data means that at no time can we or anyone else link your real identity to the information collected during this research. This means that we cannot identify you at all, even when the data is combined with other information. We will also not seek to identify you using any techniques or technology.

If you enter your name into the raffle (see *Compensation* section), data generated about you in this study will be de-identified.

De-identified. De-identified data is information that at one time could directly identify you, but that we have recorded this data so that your identity is separated from the data. We will have a list of your real name and the time stamp of your raffle entry which could potentially match the time stamp of your survey completion. While we might be able to link your identity to your data at earlier stages in the research, when the research concludes, there will be no way your real identity will be linked to the data we publish.
Data that will be shared with others about you will be anonymous.

To help maximize the benefits of your participation in this project, by further contributing to science and our community, your anonymous information will be stored for future research and may be shared with other people without additional consent from you.

Compensation

For participating in this study, you will be given the opportunity to enter into a raffle to win one of twenty $15 gift cards (Target or Amazon). To enter the raffle, click the link on the last page of the survey. The link will take you to an external form that collects your name and email address separate from the survey data.

If you withdraw from the study by not reaching the end of the survey, you will not have the opportunity to enter your name in the raffle.

What if you have questions about this study?

If you have questions at any time about the study itself or the procedures implemented in this study, you may contact the researcher, Amanda Kates by email ajgosek@ncsu.edu, or by phone 914-330-9935. You may also contact her faculty advisor, Temple Walkowiak by email tawalkow@ncsu.edu, or by phone 919-513-0918.

What if you have questions about your rights as a research participant?

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact the NC State IRB (Institutional Review Board) Office. An IRB office helps participants if they have any issues regarding research activities. You can contact the NC State IRB Office via email at irb-director@ncsu.edu or via phone at (919) 515-8754.

Consent To Participate

By clicking the link below, I am affirming that I have read and understand the above information. All of the questions that I had about this research have been answered. I have chosen to participate in this study with the understanding that I may stop participating at any time without penalty or loss of benefits to which I am otherwise entitled. I am aware that I may revoke my consent at any time.

Appendix F: Public School District Timeline

	Phase 1 August 2019	**Phase 2*** September-October 2019
Participants	Elementary Teachers from one district	School leaders (principals, assistant principals, mathematics coach)
Method of Data Collection	Teachers will receive an email invitation to complete the web-based survey.	Data will be collected through semi-structured interviews with the school leaders and document analyses of schedules, training, and the school's improvement plan.
Data Analysis Plan	Descriptive analysis will be used to determine the types of learning opportunities teachers participate (embedded or external). Multilevel analysis will be used to examine the variability in learning opportunities within and between schools.	An open-coding process will be used by first coding segments of the documents and then determining broad themes. The themes will be used to write a description of the school context as it relates to teachers' opportunities to learn.

*Results of the analyses from Phase 1, one or two schools will be purposefully selected for Phase 2 of the study.

Deliverables
The written report will be available by January 1, 2020. An oral presentation will be provided at an agreed upon date. Although there is no way to predict the findings before the study, results are likely to show that the learning opportunities within and between schools are different. Teacher and school characteristics will explain some of the variation. For example, the results may indicate that 4th and 5th-grade teachers have more opportunities to improve their mathematics instruction than K-3 teachers. Factors such as time spent discussing mathematics in a professional learning community and how closely teachers follow a Standards-based textbook might explain the differences.

Appendix G: Invitation Email to Teacher Participants

Invitation E-mail to Teacher Participant for Survey

Dear [redacted] Public School Teacher,

I am Amanda Kates, a former teacher in [redacted] and a current doctoral student at NC State University. I am writing to invite you to participate in a survey about your learning opportunities in mathematics during the 2018/19 school year. The survey includes questions about mathematics resources like textbooks, computer programs, and math manipulatives, and training like attending a conference or working with a math coach. You are eligible to participate if you:

- taught grades K-5 in [redacted] during 2018/19,
- taught math to your students, and
- was a regular classroom teacher (not special education).

The survey takes between 5 and 15 minutes to complete. Your responses are confidential; a summary of the responses at your school will be provided to the school district. At the conclusion of the survey, you have the option to enter your name in a raffle to receive one of <u>twenty-five</u> $15 gift cards. The survey is voluntary and is not required for your employment with JCPS. The link below will take you to the informed consent form and the survey.

Thank you,

Amanda Kates

Appendix H: Informed Consent Form: Survey Participants (Teachers)

Title of Study: Elementary Teachers' Learning Opportunities in Mathematics: The Case of One District **(eIRB #: 19099)**
Principal Investigator: Amanda Kates, ajgosek@ncsu.edu, 914-330-9935
Faculty Point of Contact: Temple Walkowiak, tawalkow@ncsu.edu, 919-513-0918

<u>What are some general things you should know about research studies?</u>
You are invited to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate, and to stop participating at any time without penalty. The purpose of this research study is to gain a better understanding of the opportunities elementary teachers have to learn about the mathematics they teach. We will do this through asking you to participate in an online survey.

You are not guaranteed any personal benefits from being in this study. Research studies also may pose risks to those who participate. You may want to participate in this research because you want to share about your learning experiences as a teacher of mathematics. You may not want to participate in this research because your time is limited.

Specific details about the research in which you are invited to participate are contained below. If you do not understand something in this form, please ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If, at any time, you have questions about your participation in this research, do not hesitate to contact the researcher(s) named above or the NC State IRB office. The IRB office’s contact information is listed in the *<u>What if you have questions about your rights as a research participant?</u>* section of this form.

<u>What is the purpose of this study?</u>
The purpose of the study is to investigate the types of learning opportunities in mathematics that elementary teachers in [redacted] Public Schools [redacted] had in the 2018-19 school year.

<u>Am I eligible to be a participant in this study?</u>
There will be approximately 750-900 survey participants in this study.

In order to be a participant in this study, you must agree to be in the study and have been a regular classroom teacher that taught mathematics to elementary students (grades K-5) in [redacted] Public Schools during the 2018-19 school year.

You cannot participate in this study if you were employed as a special education teacher during the 2018/19 school year.

<u>What will happen if you take part in the study?</u>
If you agree to participate in this study, you will be asked to do all of the following:

- Complete an online survey about your opportunities to learn about the mathematics you teach during the 2018/19 school year.

The total amount of time that you will be participating in this study is between 10 and 20 minutes.

Risks and benefits

There are minimal risks associated with participation in this research. A benefit is having the opportunity to identify and reflect on your own learning opportunities as an elementary teacher of mathematics which could potentially inform decisions about professional learning opportunities in [redacted] The indirect benefit is your contribution to the broader field of education about the types of learning opportunities provided to elementary teachers in mathematics.

Right to withdraw your participation

You can stop participating in this study at any time for any reason. In order to stop your participation, please stop answering the survey questions. If you choose to withdraw your consent and to stop participating in this research, your responses to the survey questions that you answer will be deleted when the data is downloaded.

Confidentiality, personal privacy, and data management

Trust is the foundation of the participant/researcher relationship. Much of that principle of trust is tied to keeping your information private and in the manner that we have described to you in this form. The information that you share with us will be held in confidence to the fullest extent allowed by law. Protecting your privacy as related to this research is of utmost importance to us. How we manage, protect, and share your data are the principal ways that we protect your personal privacy.

Data generated about you in this study will be de-identified.

De-identified. De-identified data is information that at one time could directly identify you, but that we have recorded this data so that your identity is separated from the data. Your survey link is individualized and links to your email address. However, this identifiable information will be immediately deleted from the data when it is downloaded. While we might be able to link your identity to your data at earlier stages in the research, when the research concludes, there will be no way your real identity will be linked to the school-level summary reports we produce for [redacted] and for the research we publish.

Data that will be shared with others about you will be deidentified.

To help maximize the benefits of your participation in this project, by further contributing to science and our community, your deidentified information will be stored for future research and may be shared with other people without additional consent from you. A summary of the survey responses will be provided to leaders in [redacted].

Compensation

For participating in this study, you will be given the opportunity to enter into a raffle to win one of twenty-five $15 gift cards (Target or Amazon). To enter the raffle, click the link on the last page of the survey. The link will take you to an external form that collects your name and email address separate from the survey data.

If you withdraw from the study by not reaching the end of the survey, you will not have the opportunity to enter your name in the raffle.

What if you are an [redacted] employee?
Your participation in this study is not a requirement of your employment at JCPS, and your participation or lack thereof, will not affect your job.

What if you have questions about this study?
If you have questions at any time about the study itself or the procedures implemented in this study, you may contact the researcher, Amanda Kates by email ajgosek@ncsu.edu, or by phone 914-330-9935. You many also contact her faculty advisor, Temple Walkowiak by email tawalkow@ncsu.edu, or by phone 919-513-0918.

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact the NC State IRB (Institutional Review Board) Office. An IRB office helps participants if they have any issues regarding research activities. You can contact the NC State IRB Office via email at irb-director@ncsu.edu or via phone at (919) 515-8754.

Consent To Participate

By clicking the link below, I am affirming that I have read and understand the above information. All of the questions that I had about this research have been answered. I have chosen to participate in this study with the understanding that I may stop participating at any time without penalty or loss of benefits to which I am otherwise entitled. I am aware that I may revoke my consent at any time.

I consent to participate in this research (insert Qualtrics button).

I do not consent to participating in this research (insert Qualtrics button that exits survey).

Appendix I: Email Invitations to School Principals

E-mail Invitation – School Principals

Dear XXXXXXX (Name of School Principal),

I am Amanda Gosek Kates, a doctoral student at NC State University. As you are likely aware, the elementary teachers in [redacted] Public Schools recently participated in a survey about their learning opportunities in mathematics content and pedagogy during the 2018/19 school year. The teachers were asked about their learning opportunities within the school day (e.g., using math curriculum materials, collaborating with their colleagues) as well as opportunities beyond the school day (e.g., formal training, conferences). This data collection was approved and endorsed by your district's leadership. A summary of the survey results will be provided to the district.

I am writing to invite you to participate in some follow-up work, which has also been approved by district leaders, to learn more about mathematics training and resources that were available to teachers at your school during the 2018/19 school year. The purpose of this follow-up work is to gain the perspective of school leaders about teachers' learning opportunities. I would love to learn more about your school and invite you to participate in the study through a semi-structured interview (45-60 minutes) and by providing a copy of your school improvement plan. Your participation is voluntary and is NOT a requirement of your employment with [redacted]. If you agree to participate, I would also like to invite other leaders at your school to participate (e.g., your assistant principal, curriculum coach, math coach). The results of this component of the study are for research purposes only and will not be shared with the district. Understanding the perspective of school leaders, along with teachers' reports of their learning opportunities, can inform the field of education on supporting teachers in mathematics.

Please let me know if you would be interested in participating. If you decide to participate, you will receive a $50 gift card from either Amazon or Target.

Thank you for your time, and I look forward to hearing from you.

Sincerely,
Amanda Kates

Appendix J: Email Invitation to Other School Leaders

E-mail Invitation: Other School Leaders (Assistant Principal, Coach)

Dear XXXXXXX (Name of Assistant Principal or Other Leader like Math Coach),

I am Amanda Gosek Kates, a doctoral student at NC State University. As you are likely aware, the elementary teachers in [redacted] Public Schools recently participated in a survey about their learning opportunities in mathematics content and pedagogy during the 2018/19 school year. The teachers were asked about their learning opportunities within the school day (e.g., using math curriculum materials, collaborating with their colleagues) as well as opportunities beyond the school day (e.g., formal training, conferences). This data collection was approved and endorsed by your district's leadership. A summary of the survey results will be provided to the district.

I will be interviewing your principal, (INSERT NAME), because s/he has agreed to participate in a follow-up interview. S/he also identified you as an additional leader who can provide insight. Therefore, I am writing to invite you to participate in a semi-structured interview (45-60 minutes) to learn more about mathematics training and resources that were available to teachers at your school during the 2018/19 school year. The purpose is to gain the perspective of school leaders about teachers' learning opportunities. This work has also been approved by [redacted] district leaders. However, your participation is voluntary and is NOT a requirement of your employment with [redacted].

The results of this component of the study are for research purposes only and will not be shared with the district. Understanding the perspective of school leaders, along with teachers' reports of their learning opportunities, can inform the field of education on supporting teachers in mathematics.

Please let me know if you would be interested in participating. If you decide to participate, you will receive a $50 gift card from either Amazon or Target.

Thank you for your time, and I look forward to hearing from you.

Sincerely,
Amanda Kates

Appendix K: Informed Consent Form: Interview Participants (School Leaders)

Title of Study: Elementary Teachers' Learning Opportunities in Mathematics: The Case of One District **(eIRB #: 19099)**
Principal Investigator: Amanda Kates, ajgosek@ncsu.edu, 914-330-9935
Faculty Point of Contact: Temple Walkowiak, tawalkow@ncsu.edu, 919-513-0918

What are some general things you should know about research studies?
You are invited to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate, and to stop participating at any time without penalty. The purpose of this research study is to gain a better understanding of the opportunities elementary teachers have to learn about the mathematics they teach. We will do this through asking you to participate in an interview about the learning opportunities that teachers at your school had during the 2018-19 school year.

You are not guaranteed any personal benefits from being in this study. Research studies also may pose risks to those who participate. You may want to participate in this research because you want to share about your learning experiences as a teacher of mathematics. You may not want to participate in this research because your time is limited.

Specific details about the research in which you are invited to participate are contained below. If you do not understand something in this form, please ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If, at any time, you have questions about your participation in this research, do not hesitate to contact the researcher(s) named above or the NC State IRB office. The IRB office's contact information is listed in the *What if you have questions about your rights as a research participant?* section of this form. -

is the purpose of this study?
The purpose of the study is to investigate the perspectives of school leaders on the types of learning opportunities in mathematics that elementary teachers at their respective schools had in the 2018-19 school year.

Am I eligible to be a participant in this study?
There will be approximately 6-9 school leaders (principals, assistant principals, and instructional coaches) from 2-3 elementary schools who participate, all from [redacted] Pubic Schools.

In order to be a participant in this study, you must agree to be in the study and have been in your same role at the same school in the 2018-19 school year.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to do all of the following:

1. Participate in an interview about the types of learning opportunities that the teachers at your school had to learn about mathematics during the 2018-19 school year, both within and outside the school day.

The total amount of time that you will be participating in this study is between 60 and 75 minutes.

Recording and images

If you want to participate in this research, you must agree to be audio recorded. If you do not agree to be audio recorded, you cannot participate in this research.

Risks and benefits

There are minimal risks associated with participation in this research. A benefit is having the opportunity to identify and reflect on the types of learning opportunities in mathematics that teachers at your school had during the 2018-19 school year. The indirect benefit is your contribution to the broader field of education about the types of learning opportunities provided to elementary teachers in mathematics and potentially informing how decisions are made about the learning opportunities that are provided.

Right to withdraw your participation

You can stop participating in this study at any time for any reason. In order to stop your participation, please tell the interviewer that you would like to stop. If you choose to withdraw your consent and to stop participating in this research, your responses to the interview will not be used.

Confidentiality, personal privacy, and data management

Trust is the foundation of the participant/researcher relationship. Much of that principle of trust is tied to keeping your information private and in the manner that we have described to you in this form. The information that you share with us will be held in confidence to the fullest extent allowed by law. Protecting your privacy as related to this research is of utmost importance to us. How we manage, protect, and share your data are the principal ways that we protect your personal privacy.

Data generated about you in this study will be de-identified.

entified. De-identified data is information that at one time could directly identify you, but that we have recorded this data so that your identity is separated from the data. We will have a master list with your code and real name that we can use to link to your data. Audio recordings will be destroyed, and transcripts will be de-identified if any identifying information is said during the interview. While we might be able to link your identity to your data at earlier stages in the research, when the research concludes, there will be no way your real identity will be linked to the data we publish. The results of the interviews are for research purposes only and will not be shared with [redacted] district leaders.

Data that will be shared in research publications about you will be deidentified.

Compensation
For your participation in this study, you will receive a $50 electronic gift card from Amazon or Target.

If you withdraw from the study prior to its completion, you will not be compensated.

What if you are an [redacted] employee?
Your participation in this study is not a requirement of your employment at [redacted], and your participation or lack thereof, will not affect your job.

What if you have questions about this study?
If you have questions at any time about the study itself or the procedures implemented in this study, you may contact the researcher, Amanda Kates by email ajgosek@ncsu.edu, or by phone 914-330-9935. You may also contact her faculty advisor, Temple Walkowiak by email tawalkow@ncsu.edu, or by phone 919-513-0918.

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact the NC State IRB (Institutional Review Board) Office. An IRB office helps participants if they have any issues regarding research activities. You can contact the NC State IRB Office via email at irb-director@ncsu.edu or via phone at (919) 515-8754.

Consent To Participate

By signing this consent form, I am affirming that I have read and understand the above information. All of the questions that I had about this research have been answered. I have chosen to participate in this study with the understanding that I may stop participating at any time without penalty or loss of benefits to which I am otherwise entitled. I am aware that I may revoke my consent at any time.

Participant's printed name ____

Participant's signature __________________________ Date ________________

Investigator's signature _________________________ Date ________________

Appendix L: Interview Protocol (School Leader Participants)

SAY: Thank you for participating in this interview.
Before we get started, I just want to tell you that the questions I am asking are all referring to what happened last year during the 2018/19 school year.

SAY: I would like to audio record this interview so I can focus on what you are saying. Is this okay with you? If at any point, you want me to stop the audio recorder, please let me know. START AUDIO RECORDER.

SAY: This is Amanda Kates with INTERVIEW ALPHANUMERIC ID on DATE.

SAY: We'll start with broader questions and then get more specific.

Question 1 for Coach:

- Tell me what your role was last year at school.
- Can you describe how you spent your day?

Question 1 for Principal and AP:
If you look back on last year (2018/19), overall, what would you say are your school's strengths in the area of mathematics?

2. What did you feel were areas for improvement?
   - Students
   - Teachers
   - Other Staff

3. What do you think your teachers would say?

4. Describe any initiatives your school had around mathematics during the 2018-19 school year.
   - What did that include?
   - Who was involved?
   - Who decided?
   - Do you think it was successful? How do you know?
   - How did you determine the success of the initiative?

5. Tell me about the mathematics curriculum used during the 2018-19 school year.
   - How was the curriculum chosen?
   - What were the expectations last year on how the curriculum was used in this school?
   - Who determines how the curriculum is used?
   - How was the expectation communicated to the teachers?
   - What feedback do teachers give about the curriculum?
   - You said…… and that seems to be different than what teachers say. Can you talk more about that?

6. What are other tangible resources were teachers provided for mathematics last year?
        - Are there expectations for how this is used?
        - How do you see teachers using?
        - Do you notice differences in how teachers at different grade levels use?
        - Why do you think there is a difference?

7. Tell me about PLC or PLT meetings at your school during the last academic year (2018/19).
    - How often are they focused on mathematics?
    - How often do they meet?
    - Who attends?
    - Who decides what to do?
    - What types of student data are discussed during a mathematics PLC?
    - What type of activities do teachers participate in during a mathematics PLC?
    - Do you notice different things happening at different grade levels?
    - Is this different for other content PLCs?

8. Did teachers meet with a vertical PLC?
    - What was the purpose?
    - What types of activities did teachers engage in during those meetings?

9. Tell me about mathematics coaching that occurred during the 2018/19 school year.
    - How did you define the role of the coach?
    - What types of activities does the coach do with teachers?
    - Where do they meet?
    - Is it with a group or individual?
    - Is there any type of plan?
    - How is it decided?
    - Who does the coach to work with?

10. What types of opportunities did teachers have to participate in professional development related to mathematics during the 2018-19 school year?
    - What was the process for determining the focus of the PD?
    - What is your typical process for determining the focus or topics for PD?
    - How do you decide which teachers attend PD?
        - Are there any expectations for teachers to share what they learned?
        - When does that happen?
        - What have they shared?
    - Do you feel the PD was beneficial?
        - Is there any evidence that supports that?

11. Is there anything else you could share that would help me understand the mathematics instruction during the 2018/19 school year?

Appendix M: Double Sorted Activities

Mathematical Knowledge for Teaching (MKT)

Ball, Thames & Phelps, 2008

	Common Content Knowledge How do I understand the concept?	**Specialized Content Knowledge** How is this concept decomposed?	**Knowledge of Content and Students** How do my students understand this concept?	**Knowledge of Content and Teaching** How can I best teach this concept?
Content What to Teach	• Find resources • Solve the problems planned for a future lesson	• Find resources • Connect new content to previously taught concepts	• Differentiate lesson plans to meet needs and interest of students • Anticipate how students will solve a problem	• Plan instruction • Plan uses of manipulatives • Share resources • Connect lesson to other subjects
Pedagogy How to Teach	• Work with others to solve problems • Explain my thinking • Solve mentally	• Explain thinking • Use manipulatives and drawings to model mathematics	• Share different solutions to the same problems • Play a mathematics game • Complete a student assessment	• Observe instruction • Practice an instructional strategy
Student Learning Why Teach This Way	• Reflect on how new information compares with current beliefs and practices	• Analyze student work • Use progression documents • Match lesson goals with grade level Standards • Reflect on differences between doing and teaching mathematics	• Analyze my students' work • Listen to student thinking • Discuss common solutions and errors • Use student work to guide instructional decisions	• Discuss what representations would support student thinking • Reflect on how new information compares with current beliefs and practices