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Abstract

The commitment of resources to coaching almost always occurs in interaction with other district-wide efforts to improve instruction. Given this probable situation, it's concerning that the field lacks the ability to provide guidance regarding how coaches might reasonably be integrated within overall plans for the coordination and improvement of instruction. Indeed, the field lacks a robust understanding of coaching beyond a siloed- endeavor or theories of coaching as one aspect of a district's broader system for instructional improvement (i.e., the *educational infrastructure*). Infrastructure refers to "the coordinated roles, structures, and resources that school systems design and use to support and coordinate instruction, maintain instructional quality, and enable instructional improvement" (Cohen, Spillane, & Peurach, 2018, p. 205). In this dissertation, I examine and articulate relations between infrastructure for elementary mathematics and mathematics coaching. To do this, I utilize a cross-case analysis of two school districts with different infrastructure designs for elementary mathematics. I then surface similarities and differences between coaching practice in each district and show how they are related to key variations in the districts' infrastructure within which these coaches work. More specifically, this dissertation addresses three questions: 1) What is the design of infrastructures for elementary mathematics in two school districts? 2) How do coaches enact their role in these different infrastructure designs? 3) How do variations in district infrastructures for elementary mathematics shape coaching practice?

I show that both districts adopted similar visions for students' mathematical learning and instruction. To achieve these visions, both districts designed infrastructure to guide and support school leaders and teachers as they endeavored to improve elementary mathematics teaching. These designed infrastructures included formal role groups that were designed to engage in issues of instructional improvement, resources designed to "carry" the district vision to various communities across the district such as instructional materials and assessments, and designed participation structures for various role groups to participate in to learn about the district vision for mathematics teaching and learning. Coaches were a key component in both districts' infrastructures.

While the two infrastructures had similar component parts, I show that the districts made different strategic choices regarding 1) who was connected through designed participation structures, 2) how clear and detailed the designed resources were, 3) the extent to which there were designed mechanisms to encourage adherence to the vision espoused in the infrastructure, and 4) the extent to which all the infrastructure components cohered around the adopted vision for mathematics teaching and learning.

Further, I show that while math coaches in both districts engaged in several common tasks, including planning and facilitating teacher professional learning, observing and debriefing teachers' instruction, and building district level capacity, among others, their enactments were different in several consequential ways, including how they divided time among various tasks, who they co-enacted tasks with, what resources they used and how, and the focus of their interactions. I show that these differences were related to the differences in the broader

infrastructures within which coaches worked. For example, I found that the degree to which the design of the coaching role was integrated with other levers for improvement, joined with an overall press for the vision of mathematics infrastructure espoused in the infrastructure, shaped the relative balance in time coaches spent on various coaching tasks. In this way, I show how infrastructure design shaped lived coaching practice.

By broadening our notion of coaching practice beyond the individual coach and their knowledge, beliefs, and actions, this dissertation contributes to understandings of how coaching is couched within and interacts with the larger instructional improvement system. It also uncovers opportunities for intervention for those designing infrastructure to support the implementation of ambitious instructional reform in mathematics.

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Chapter 1
Introduction

For many teachers, aligning their instruction with the Common Core State Standards in Mathematics (CCSS-M) has required new knowledge, strategies, and deep-seated changes in their understandings of the ways in which students learn mathematics (Ball & Cohen, 1999). Providing teachers across many schools with opportunities to learn how to make these shifts has become a central task for district leaders (Hightower et al., 2002), and instructional coaching (henceforth coaching) has emerged as a popular tool that districts use in their instructional improvement efforts (Mangin, 2009; Coburn & Russell, 2008; Coburn & Woulfin, 2012).

There is no singular definition of coaching in education (Poglinco et al., 2003; Taylor, 2008). In general, coaches are understood to be more-expert colleagues who fill a variety of instructional support or policy implementation roles (Woulfin & Rigby, 2017; Galey, 2016). These roles include facilitating professional learning sessions, observing instruction and providing feedback to teachers, and leading teacher professional learning communities (PLCs). Coaching reflects new understandings and beliefs about learning (Bransford, Brown, & Cocking, 2000; Lave & Wenger, 1991) and the kinds of learning opportunities that are most likely to produce change in practice—opportunities that are sustained, situated within teachers' day-to-day work, and focused on matters of instruction (Fishman et al., 2003; Putnam & Borko, 2000; Garet et al., 2001). Regardless of the various forms that coaching can take, there is the consistent expectation that a coach's day-to-day work will positively influence classroom instruction and ultimately student achievement.

The evidence on coaching's effectiveness, however, is mixed. Several studies demonstrate a link between coaching and teacher learning (Stein et al., 2021; Sun et al., 2014) as well as coaching and a change in instruction (Correnti et al., 2021; Matsumura, Garnier, & Resnick, 2010; Neuman & Cunningham, 2009). A small number of studies have found coaching effects on student achievement (Biancarosa et al., 2010; Correnti et al., 2021; Elish-Piper & L'Allier, 2011).

At the same time, other studies have produced indecisive or null coaching effects (Garet et al., 2008; Murray, Ma, & Mazur, 2009; Van Keer & Verhaeghe, 2005; Gamse et al., 2008). Still other studies indicate that coaches spend relatively little time working with teachers, reporting percentages as low as 28 percent (Deussen et al., 2007) and 35.7 percent (Bean et al., 2010) on average. Several scholars have attributed this mixed evidence on coaching to the fact that coaching is a complex practice and coaching can look very different depending on how coach roles are structured and enacted (Coburn & Woulfin, 2012; Mangin, 2009; Mangin & Dunsmore, 2015). This suggests that we need a better understanding of the varied ways the coach role is designed and what coaches are actually doing when they enact their roles. Research that has engaged with the particulars of coaching has mostly focused on the characteristics of coaches such as strong interpersonal skills, tact, patience, good communication skills, and flexibility (Neumerski, 2012; Poglinco et al., 2003; Blamey, Meyer, & Walpole, 2009), as well as the roles and responsibilities that they take on (Deussen et al., 2007; Vanderburg & Stephens, 2010). More recently, a few studies have begun to identify conditions that facilitate coaching such as a supportive principal and school level norms of collaboration (Huguet, Marsh, & Farrell, 2014;

Mangin, 2009). These latter studies begin to move our understanding of coaching forward by locating reasons for the success (or failures) of coaching in circumstances outside the role of the coach; at the same time these studies run the risk of producing a laundry list of factors that must be satisfied for coaching to "work."

Despite these efforts, research has not kept pace with the realities on the ground in many school districts, especially the needs of school and district leaders who initiate and oversee large-scale coaching initiatives aimed towards achieving sweeping improvements in teaching practice across a district (Domina et al., 2015; Mangin, 2009). Leaders across the country—with little understanding of how coaches can successfully be incorporated into broader systems of instructional support—have been designing coaching initiatives and deploying hundreds of coaches each year (Domina et al., 2015). It is not surprising then that in a recent meta-analysis, researchers found that the positive effects of larger-scale coaching initiatives (those which are likely more realistic in a broader policy context) were roughly half as large as those of smaller-scale coaching programs implemented under best-case scenarios (Kraft et al., 2018).

The commitment of resources to coaching almost always occurs alongside other district-wide efforts to improve instruction. For example, the district may adopt a new curriculum, create a classroom walkthrough routine, or introduce PLCs where teachers are expected to examine and use student data. Given this probable situation, it's concerning that the field lacks the ability to provide guidance regarding how coaches might reasonably be integrated within overall plans for the coordination and improvement of instruction. Despite researchers'

increased ability to list or articulate what coaches do and even some research that has been able to make claims about behaviors or conditions that lead to greater coaching effectiveness, the field lacks a robust understanding of coaching beyond a siloed- endeavor or theories of coaching as one aspect of a district's broader system for instructional improvement (Hopkins et al., 2013). In short, the field has limited knowledge regarding how coaching is couched within and interacts with the larger *educational infrastructure*.

Educational infrastructure (henceforth infrastructure) refers to "the coordinated roles, structures, and resources that school systems design and use to support and coordinate instruction, maintain instructional quality, and enable instructional improvement" (Cohen, Spillane, & Peurach, 2018, p. 205). Infrastructure is a district's design for improvement at the system-level. For example, many districts create new positions for mathematics coaches (roles), organize PLCs of teachers (structures), and develop curriculum frameworks to align instruction (resource) in order to support teachers as they navigate the new content and instructional shifts called for in the CCSS-M. District infrastructures across the country vary significantly due to the decentralized system of education in the U.S. (Cohen & Spillane, 1992), and research suggests that these variations are important to consider for school and district practice (Spillane, Hopkins, & Sweet, 2018; Spillane, Shirrell, & Hopkins, 2016; Hopkins et al., 2013; Stein & Coburn, 2008; Coburn & Russell, 2008; Spillane, Parise, & Sherer, 2011). To date, however, there have been few studies that have specifically examined the role coaches play in broader infrastructures and how those infrastructures shape coaching practice.

In this dissertation, I examine and articulate relations between infrastructure for elementary mathematics and mathematics coaching. To do this, I utilize a cross-case analysis of two school districts with different infrastructure designs for elementary mathematics. I then surface similarities and differences between coaching practice in each district and show how they are related to key variations in the districts' infrastructure within which these coaches work. More specifically, this dissertation addresses three questions: 1) What is the design of infrastructures for elementary mathematics in two school districts? 2) How do coaches enact their role in these different infrastructure designs? 3) How do variations in district infrastructures for elementary mathematics shape coaching practice?

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While the two infrastructures had similar component parts, I show that the districts made different strategic choices regarding 1) who was connected through designed participation structures, 2) how clear and detailed the designed resources were, 3) the extent

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Further, I show that while math coaches in both districts engaged in several common tasks, including planning and facilitating teacher professional learning, observing and debriefing teachers' instruction, and building district level capacity, among others, their enactments were different in several consequential ways, including how they divided time among various tasks, who they co-enacted tasks with, what resources they used and how, and the focus of their interactions. I show that these differences can be accounted for by the differences in the broader infrastructures within which coaches worked. For example, I found that the degree to which the design of the coaching role was integrated with other levers for improvement, joined with an overall press for the vision of mathematics infrastructure espoused in the infrastructure, shaped the relative balance in time coaches spent on various coaching tasks. In this way, I show how design, in this case infrastructure design, shape lived practice (in this case coaching practice).

I draw out this argument in the chapters that follow. After this introduction, I motivate this study by reviewing the literature on coaching and what we know about how coaching works in interaction with other district levers for instructional improvement (Chapter 2). In Chapters 3 and 4 I introduce my conceptual frame, research design, and methodology for this dissertation. In chapter five I describe both districts' infrastructure designs for elementary mathematics. In chapter six, I compare and contrast the two designs along four dimensions. In

Chapter 7, I discuss how coaches enact their roles through two district case studies of coaching practice. In each case study I show the tasks coaches engaged in and the nature of coaches' interactions that constituted these tasks. I end the chapter by drawing out key differences in coaches' practice in the two districts through a cross-case analysis. Finally, in Chapter 8 I draw links between infrastructure design and coaching practice through a cross-case analysis of coaching practice in my two districts. I conclude the dissertation in Chapter 9, drawing implications of my findings for research and practice.

Chapter 2
Literature Review

Armed with studies pointing to the potential value of coaching (e.g., Biancarosa, Bryk, & Dexter, 2010; Campbell & Malkus, 2011; Neuman & Cunningham, 2009; Correnti et al., 2021), districts across the country are designing and implementing coaching initiatives as part of their overall plan for instructional improvement. Research suggests that coaching is an important feature of district-wide improvement initiatives (Cobb & Jackson, 2011; Coburn & Russell, 2008; Hopkins, Ozimek, & Sweet, 2016), yet much of the extant literature explores coaching as an individual and decontextualized task, delineating characteristics of coaches (Poglinco et al., 2003; Blamey, Meyer, & Walpole, 2009) and their roles and responsibilities (Deussen et al., 2007; Coburn & Woulfin, 2012). Studies that do attend to context have begun to specify specific features of school and district contexts that are important facilitators of coaching (Huguet, Marsh, & Farrell, 2014; Mangin, 2009), but this research tends to view these features as a backdrop (or as conditions that must be met), not as an integral component of coaching (Neumerski, 2012). Further, the research on context treats coaching as a siloed support to teachers instead of recognizing the "multifaceted nature of the educational infrastructure" within which coaching takes place (Spillane, Hopkins, & Sweet, 2018, p. 560).

In this chapter, I review the literature on coaching to motivate this dissertation study. I begin my defining what I mean by an "instructional coach." Then I review what we know about the potential of coaching. This section primarily reviews experimental or quasi-experimental studies. I then turn to a section where I review the particulars of the coaching role and what we know about the influence of school and district context. In the final section of the literature

review, I turn to the small, but growing body of research on infrastructure and argue that we need a better understanding of how coaching fits into and interacts with the broader district infrastructure.

What is an Instructional Coach?

Coaching is one form of instructional leadership (Spillane, Halverson, & Diamond, 2001). By instructional leadership I mean "the performance of a set of functions that establishes goals for instruction and engages others in the process of classroom instruction and instructional improvement" (Taylor, 2008. P. 12). Although coaching roles are designed to share some of the same leadership functions as other types of instructional leaders (e.g., principals), there are three functions that set the coaching role apart. First, a coach's primary function is to work directly with teachers (one-on-one or in small or large groups) to improve their instruction. This does not preclude coaches from performing other functions; but direct work with teachers is, at least theoretically, at the heart of the role. Second, the coach role is designed to be non-supervisory and non-evaluative. Instead of evaluating teachers, coaches are charged with developing trust and norms of collegiality, providing constructive feedback, and pressing teachers to self-reflect on their practice. Third, coaches operate within the classroom setting or with artifacts from the classroom setting (e.g., curriculum) more than do other types of instructional leaders (Taylor, 2008). To be clear, these functions reflect how many coaching roles are designed, not how they often play out. For example, there is research to suggest that coaches can spend almost no time in classrooms or with teachers and that principals can use coaches to evaluate teachers (Bean et al., 2010).

Beyond these three broad functions, the coaching role can be configured in many ways (Taylor, 2008; Poglinco et al., 2003). Simply knowing that a district has hired coaches or that coaches are working with teachers reveals little about how coaches are situated within the organization or how they spend their time. Coaches can be content-specific (e.g., mathematics or literacy) or they can be generalists who work with teachers across all content areas. Structurally, coaches can be connected to schools and teachers in many ways. On one end of the spectrum are on-site coaches who are based in the school. Sometimes these types of coaches are referred to as teacher leaders or peer coaches and may be full-time coaches or part-time coaches who spend the other portion of their time in the classroom as a teacher. On the other end of the spectrum are off-site coaches who are part of a district's central administration. These types of coaches are almost always full-time and are deployed to work with schools and teachers based on need or some other sort of district-developed metric. Additionally, they often take on other district level capacity-building roles such as developing curriculum or designing and conducting district professional learning sessions (Taylor, 2008).

For the purposes of this dissertation, I focus on a specific kind of coaching: coaches that are full-time, content specialists in mathematics, and who are organizationally situated off-site within the district's mathematics department. In line with research that differentiates coaches from other types of instructional leaders, I will also focus on coaches whose primary responsibility (although they may have others) is to work closely with teachers and instructional materials to develop teachers' instructional capacity in a non-supervisory and non-evaluative

manner. My findings will not speak to coaches that are defined in another way (e.g., a coach who is part-time or whose responsibilities are primarily administrative).

The Potential of Coaching

The evidence emerging from the coaching effectiveness literature is mixed. On the one hand, research shows positive associations between coaching and teacher learning (Sun et al., 2014), coaching and changes in teacher practices (Blazar & Kraft, 2015; Stein et al, 2021), and coaching and increases in student achievement (Biancarosa, Bryk, & Dexter, 2010; Correnti et al, 2021). In a 2017 meta-analysis, Kraft, Blazar, & Hogan (2017) estimated the mean effect of coaching programs on teachers' instructional practice and students' academic achievement and found positive pooled effect sizes on both (0.49 SD on instruction and 0.18 SD on student achievement). These studies suggest that coaching can "work" and is a worthwhile instructional improvement lever for districts to pursue.

On the other hand, several studies have produced indecisive or null coaching effects (Garet et al., 2008; Murray, Ma, & Mazur, 2009; Van Keer & Verhaeghe, 2005; Gamse et al., 2008). As an example, Garet and colleagues (2008) studied the impact of two research-based PD interventions for reading instruction on both instructional improvement and student achievement. As part of their experimental design, they employed two treatment groups: one group received content-focused professional development that began in the summer and continued through much of the school year and the other group received the same professional development plus in-school coaching. They found no statistically significant effect of the coaching intervention on teacher practices or student test scores (i.e., over and above the

professional development-only treatment) at the end of the one-year treatment or in the year following the treatment (Garet et al., 2008).

What do we make of this mixed evidence? Several scholars have pointed to the fact that coaching is a complex practice that is inherently variable (Coburn & Woulfin, 2012; Mangin, 2009; Mangin & Dunsmore, 2015). Developing measures of both coaching and coaching outcomes is difficult and researchers have acknowledged this limitation. For example, Campbell & Malkus (2011) conducted a 3-year randomized control trial to study the effects on student achievement of placing mathematics coaches in elementary schools to provide on-site, collaborative professional development; they found positive effects on student achievement. Their conceptual model identified variables that may explain or interact to influence the effect of coaches, recognizing the many mediating variables between coaching and increases in student achievement (e.g., teacher beliefs). The quantitative nature of their data, however, did not allow them to explore those variables; they conclude that "field investigations are needed if we are to understand how to maximize the potential of coaching" (Campbell & Malkus, 2011, p. 451). There is a tendency in effectiveness studies to treat coaching as a monolithic improvement initiative, obscuring the particulars of the coaching design as well as the nuances of implementation. All of this suggests that we need a better understanding of what coaches are actually doing. A growing body of work has begun to engage with the particulars of coaching, and I turn to a review of this literature next.

The Coaching Role

Most research on coaching, dating back to the idea of "peer coaching" (Showers & Joyce, 1996), focuses on the characteristics of coaches and the activities in which they typically engage. Studies that examine characteristics point to three broad categories of skills that coaches typically possess: pedagogical knowledge, content expertise, and interpersonal skills (Kowal & Steiner, 2007). It is widely accepted that coaches should be experienced teachers who have demonstrated success in the classroom and experts in the content area in which they are coaching, whether it be a subject area like mathematics or a general strategy like differentiated instruction (Feger, Woleck, & Hickman, 2004). Less is known about the specific interpersonal capabilities that coaches often possess, but studies have highlighted characteristics such as tact, patience, and ability to establish trust and credibility (Poglinco et al., 2003).

The literature on what coaches do surfaces the variability, complexity, and mutability of the role. Coaches can have many kinds of roles and responsibilities, and these can change day-to-day, as well as differ between coaches in the same school and between schools within the same district (Galey, 2016). Some roles are directly related to instructional improvement. This type of work often includes giving targeted feedback, helping teachers with data interpretation, and orchestrating PLCs, workshops, and other group professional development activities (Coburn & Russell, 2008; Horn, Kane, & Wilson, 2015; Mangin & Stoelinga, 2008). Other educative coaching activities include lesson modeling, co-teaching, and Lesson Study (Neufeld & Roper, 2002; Gallucci et al., 2010; Mudzimiri et al., 2014). Coaches can also be diverted from these educative activities and asked to assume administrative roles, such as assisting principals

with administrative duties, preparing lesson materials for teachers (e.g., printing, lamination), or proctoring student assessments (Deussen et al., 2007; Bean et al., 2010). In a study of Reading First coaches, Bean and colleagues (2010) found that on average, coaches spent only 35.7% of their time directly working with teachers. The rest of their time was spent planning and organizing for the work they would do with teachers, completing administrative tasks, participating in school-related meetings, and working directly with students.

In addition to educative and administrative roles, research shows that coaches can also take on a political role (Coburn & Woulfin, 2012). In their study of Reading First implementation in one Massachusetts school, Coburn and Woulfin (2012) found that in addition to conveying instructional messages, coaches also advised teachers on how to take up the Reading First initiative by emphasizing some parts of the policy and deemphasizing others. By "pressuring, persuading, and at times buffering" (Coburn & Woulfin, 2012, p. 13) teachers during coaching interactions, coaches were critical in shaping teachers' uptake of the policy.

While research has been able to identify the roles and broad responsibilities of coaches, researchers have not examined the actions and interactions in which coaches engage at a more micro level. That is, there is a relative dearth of research that examines coaches' lived practice, including the nature and content of their interactions. As an exception, Mudzimiri and colleagues (2014) observed seven mathematics coaches across five districts and found that the content of coaching sessions focused on mathematics content and pedagogy, instructional reflection, students' thinking and actions, classroom management, curriculum issues, resources and professional development, and feedback and goal-setting. Moreover, coaches were found

to employ strategies that were about building relationships, informational exchange, and facilitating teacher learning. In another exception, Woulfin (2015) conducted an observational study of coaching in which she demonstrated ways in which coaches packaged district reform messages that resonated with specific teachers in particular contexts to facilitate and motivate change in teacher practice. For example, when coaches used their social skill (Fligstein, 2001) to sense that teachers were frustrated with what they were being asked to do, coaches employed the tactic of "accepting incremental change." As the name suggests it permitted small-step changes in teachers' practice.

Together, existing research suggests that coaches can enhance teacher learning, bolster PLCs, create opportunities for deep interactions among school staff, and affect the quality and integrity of policy implementation. Moreover, these studies provide evidence that coaching is not a monolithic practice; it consists of different forms of support at different times and often depending on in-the-moment decisions that coaches make. Nonetheless, these findings derive from studies that focus on coaching as an individual activity; thus, it is not clear how coaches interact with other roles, structures, and resources in district or school-wide reform efforts. Although some nod toward the influence of context, these studies mostly treat coaching in a decontextualized manner, as though one could pick up a set of coaching behaviors in one setting and transport them to another. I turn next to literature that more directly grapples with coaching contexts and broader systems.

The Context of Coaching

School context and the influence of the principal has garnered the lion's share of researchers' attention. Across studies, school-level administrators are identified as driving forces in the change processes that occur in their school by virtue of the authority they hold with teachers (primarily because the principal evaluates teachers), the power over coaching resources and responsibilities, as well as their mediation of policy messages (Matsumura & Wang, 2014; Matsumura et al., 2009; Marsh, Bertrand, & Huguet, 2015; Huguet, Marsh, & Farrell, 2014). For example, Matsumura and colleagues (2009) explored the principal's role in launching a new content-focused literacy coaching program and found that principals' public endorsement of the coach as a source of expertise and their active engagement in coaching activities with teachers were associated with more frequent teacher-coach interactions.

Other studies that foreground the role of the principal suggest that principals' sensemaking of the reform (Matsumura & Wang, 2014), their overall vision for instructional change in their school (Marsh, Bertrand, & Huguet, 2015), and their mediation of political struggles (Huguet, Marsh, & Farrell, 2014) all influence coaching practice. This suggests that principals (even well-intentioned ones) can thwart well-designed coaching initiatives because of their authority and influence over the ways in which their faculty view coaching and the reform as well as the way coaching is able to play out in their school. Even a principal's power over something as mundane as scheduling is worth noting; for example, one study found that principals impeded coaching in their schools by not setting aside enough time for teachers and coaches to meet (Marsh, Bertrand, & Huguet, 2015).

A much smaller body of research attends to district context. These studies suggest that district leaders—their beliefs and perceptions, the decisions they make about the design of coaching, and how they frame coaching initiatives—are consequential (Mangin 2009, 2014; Mangin & Dunsmore, 2015; Firestone & Martinez, 2007; Coburn & Russell, 2008). In a series of studies, Mangin (2009, 2014) showed how the beliefs and perceptions of district leaders shaped coaching implementation. In one study of 20 school districts that participated in a literacy coach training program, Mangin (2009) delineated three different coaching models: 1) classic (a model where coaches primarily worked with teachers on instructional improvement), 2) modified (a model where coaches had to engage in activities in addition to instructional improvement), and 3) no model (Mangin, 2009, p. 769). Leaders in districts that implemented *classic* coaching models reported perceiving factors, like national and state mandates, accountability standards, and student performance data as responsible for their selection of the classic model. Districts using the *modified* or *no* model more frequently reported factors like limited finances and satisfactory student performance (Mangin, 2009). These studies emphasize that districts' organizational support and norms are key factors in whether and what kind of coaching design is implemented in districts undergoing reform.

Very few studies have traced how district context influences coach practice, that is, what coaches do on-the-ground. The studies that do, have found that districts may have far greater influence than previously thought (Honig et al., 2010); factors that were found to shape coaching ranged from administrative or operational decisions such as budgeting (Marsh, Bertrand, & Huguet, 2015) to substantive ones like the design of the coaching initiative (Coburn

& Russell, 2008). Coburn and Russell (2008) explored how district policies (most prominently a coaching initiative) influenced teachers' social networks during the scale-up of a new mathematics curriculum in two school districts. They found that coaching alone did not influence interactions between coaches and teachers. Instead, district-level decisions about the selection and training of coaches, their roles and responsibilities, and the focus of coaches' professional development, influenced teachers' access to expertise as well as the degree to which teachers' interactions were deep and substantive (Coburn & Russell, 2008). This study is noteworthy because it shows that district-level policy, seemingly distant from the "street-level" (Weatherly & Lipsky, 1977) work of coaches and teachers, shaped what they talked about and how they interacted.

Mangin and Dunsmore (2015) explored whether the district framing of coaching (as measured through the training coaches received) shaped the way in which coaches enacted their roles. They found that the coach training framed coaching as a means to support individual teacher learning. Consequently, coaches employed strategies that mirrored the theory of change evident in the training program, which focused on coaches being responsive to individual teacher's particular needs, often at the expense of school and district goals. As Mangin and Dunsmore (2015) explain, "The logic that coaches used to explain how individual coaching could facilitate school-wide change hinged on their understanding of systemic reform as synonymous with an aggregation of individual changes across teachers" (Mangin & Dunsmore, 2015, p. 196). Districts have begun to recognize the promise of coaching in supporting instructional improvement on a large scale, but this study surfaces the tension

between collective goals and individual needs. Further, this study points to the need for research on how coaches' work can be connected to the district's systemic reform agenda in coherent ways that optimize the role the coach is able to play in instructional improvement.

While these studies begin to investigate the role of district and school context in how coaches do their work in different settings, they continue to examine coaching as a siloed instructional improvement endeavor. Coaching, however, is almost always just one component of a broader system of supports for instructional improvement (i.e., the infrastructure) such as instructional materials and assessments, professional learning opportunities for school leaders, and other forms of professional development for teachers. In the final section of this literature review, I present research that suggests that to understand coaching practice we need to move beyond studies that conceptualize coaching as an individual, decontextualized task. To do this I draw on a growing body of literature that explores the ways in which broader infrastructures for instructional guidance and improvement influence school and district practice.

Coaching and Educational Infrastructure

Coaching is just one component of a district infrastructure for instructional guidance and improvement. Though it is often taken-for-granted and overlooked (Star, 1999), scholars have long argued that infrastructure is important (Cohen & Spillane, 1992). In addition to providing guidance and support to teachers, it can structure or "frame and focus" (Spillane, 2015, p. 281) interactions among district and school staff about teaching and learning. Research on the relationship between infrastructure and practice is just now emerging and studies tend to be inconsistent in their conceptualizations of infrastructure. Here, I draw on studies of

infrastructure that recognize the ways in which interdependent components shape instructional reform efforts on the ground (Spillane, Hopkins, & Sweet, 2018; Hopkins et al., 2013; Hopkins & Spillane, 2015). Using this conceptualization, Spillane and colleagues (2018) explored how system-level changes in a district's infrastructure facilitated changes in teachers' beliefs about mathematics instruction at scale. They found that while the adoption of a new mathematics curriculum was an important component, understanding how it worked to shift teacher beliefs required attention to the ways in which it worked in interaction with other components of the infrastructure including formal leadership positions and organizational routines. Stein & Coburn (2008) refer to this interdependent system as the district's "architecture for learning" and explain that "while district leaders cannot force or guarantee teacher learning, they can design the conditions that will be supportive of the kinds of interactions that will provide opportunities for meaningful teacher learning" (p. 585).

Despite coaching being a key component in most school and district infrastructures, most studies of coaching are silent on how coaching interacts with or is shaped by the rest of the improvement system (Hopkins et al., 2013; Hopkins, Ozimek, & Sweet, 2018). Practically, this is problematic because with little guidance for how coaching roles can be designed and productively integrated with other improvement endeavors, district and school leaders often end up layering coaching initiatives on top of other improvement efforts without much consideration. The few studies that have begun to explore the relations between coaching and broader infrastructure suggest that coaching alone does not influence school and district practice (Hopkins et al., 2013; Coburn & Russell, 2008; Hopkins, Ozimek, & Sweet, 2018). For

example, Hopkins and colleagues (2013) studied one district's infrastructure redesign efforts in mathematics that included new coach positions. Using social network analysis to explore relations between infrastructure and school practice (as captured in advice-and-information-seeking interactions among school staff), they found that coaches emerged as central actors and brokers of advice and information about mathematics (although to varying degrees) both within and between schools. That is, the infrastructure redesign influenced who teachers interacted with, when, where, and to a certain extent why (i.e., teachers saw coaches as people with expertise). Critically, they explain that their findings cannot disentangle the independent effects of different infrastructure components (e.g., professional development); in fact, their account suggests the new components worked in interaction with other components of the district's infrastructure. The nature of this study, however, prevented them from attending to the content and nature of the coaching interactions so how coaches engaged with the infrastructure is obscured.

To summarize, I have argued that to understand the mixed evidence emerging from effectiveness studies of coaching, we need research that explores the particulars of coaching. Research that attends to what coaches actually do tends to treat coaching as a siloed and decontextualized instructional improvement initiative. This is problematic because coaching is always one component of a much larger infrastructure that together works to guide, support, and improve teachers' instruction. Yet, we lack a clear understanding of the relations between coaching and broader infrastructure for instructional improvement. This dissertation addresses this gap in a study of two school districts that are implementing coaching initiatives as part of

their mathematics instructional support strategies for elementary teachers as they work to align their instruction with the CCSS-M.

This dissertation addresses the core question: What is the relationship between mathematics coaches' practice and broader infrastructures for instructional improvement in elementary mathematics? Three empirical questions follow:

1. What is the design of infrastructures for elementary mathematics in two school districts?
2. How do coaches enact their role in these different infrastructure designs?
3. How do variations in district infrastructures for elementary mathematics shape coaching practice?

Chapter 3
Coaching as a Distributed Practice

In this dissertation, I conceptualize coaching as a distributed practice (Spillane, 2006; Spillane & Diamond, 2007; Spillane, Halverson, & Diamond, 2004). In this view, practice is differentiated from the actions of individual people; instead, practice is about interactions among people while they engage in tasks together (Lave & Wenger, 1991; Wenger 1998; Spillane, 2006). Taking a distributed perspective on practice requires systematic attention to the cultural and material context in which interactions are situated because we cannot understand human activity without considering the context in which it takes place (Spillane, 2006). Practice, therefore, is defined as *interactions that are mediated by aspects of the situation*. This perspective is rooted in "situated" theories of learning such as distributed cognition and cultural-historical activity theory, both of which mark a break from traditional cognitive science theories by recognizing that mental processes are inextricably linked to the situation or context in which they occur (Hutchins 1995; Lave & Wenger, 1991).

Given this central premise – that all human activity is social and situated – taking a distributed perspective broadens the unit of analysis from the individual, including their knowledge, beliefs, and actions, to the individual in interaction with others and the cultural and material artifacts in particular situations. This perspective does not diminish the role of an individual's own knowledge, beliefs, and actions; instead, it suggests that they cannot be understood in isolation from the situation. While many aspects of a situation may be important, the distributed perspective draws particular attention to persistent or durable tools, artifacts, resources, and organizational structures that "stretch over" situations and activities (Spillane,

Halverson, & Diamond, 2001, p. 23). These aspects of the situation do not entirely define practice; instead, the situation is both the medium within which humans act and the outcome of their actions (Giddens 1979, 1984). It follows that the situation and its tools, artifacts, resources, and structures can both enable and constrain practice.

Taking a distributed perspective of coaching suggests attention to a few things. First, attention must be paid to the interactions (as opposed to the actions or behaviors) that coaches engage in with others. We know from the literature on coaching that coaches interact with teachers but are also situated in a unique organizational position that requires working across organizational levels (district, school, classroom) with other types of role groups like school principals, district leaders of various sorts, as well as other coaches to enact their role. All these interactions are important to account for because together they constitute coaching practice.

Second, because the distributed perspective is grounded in activity rather than in position or role, this perspective requires a consideration of the tasks around which coaches organize their practice. The coaching literature identifies several tasks that figure prominently in coaches' practice. These tasks include observing and debriefing instruction, lesson planning, co-teaching a lesson, and analyzing student work or assessment data with teachers among others. The literature also points to tasks that are adjacent to coaches' primary role of working with teachers such as covering classes, proctoring assessments, or managing grants.

Third, the distributed perspective suggests attention to the situation as a constituting element of coaches' interactions with others. To sharpen my conceptualization of the coaches' situation, I treat district infrastructures for elementary mathematics as the situation within

which coaches interact. Educational infrastructures, by their very nature, are composed of resources, materials, tools, or artifacts that are persistent because they are designed to travel time and space (Wenger, 1998, p. 179). As Stein and Coburn (2008) explain:

> Because district leaders seldom interact directly with the teacher communities they seek to influence, they identify or create "stuff" that embodies their vision (e.g., curricular framework, directives, or procedures) and launch them on journeys that cross the boundaries of a variety of communities (p. 585).

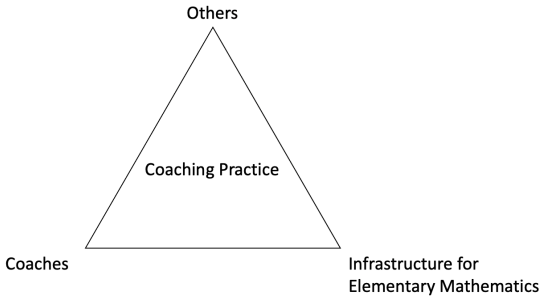
Along with resources, infrastructures often include organizational structures or routines (e.g., PLCs, weekly coaching meetings, classroom walkthroughs) that create opportunities for interaction (and potential learning) around the resources.

Fourth, the distributed perspective suggests attention to the way infrastructures for elementary mathematics can both structure coaching practice and at the same time be the outcome of coaching practice. To operationalize both structure and agency, I distinguish between two aspects of an infrastructure: the designed infrastructure and the lived infrastructure (Wenger, 1998). The designed infrastructure refers to the formally designated roles, the actual design of materials, resources, or tools (and plans or protocols for their use), as well as the design of participation structures and plans or expectations for how they are to be utilized. The lived infrastructure is the way these designs play out in practice. The lived privileges the ways in which roles are enacted, resources are taken up and used in practice, and how participation structures look when they get played out. The designed does not fully define the lived. Indeed, infrastructure components are designed by district leaders with ideas about how they are going to be used. They may even be accompanied by directives or mandates that outline how they should be used. Yet there is no way to fully account for how infrastructure

components will be utilized. Take, for example, curriculum, a concrete material artifact that is a central component of most infrastructures. It has a designed aspect (the tangible pages that compose the curriculum materials) and a lived aspect (the ways in which teachers utilize the curriculum or the ways in which coaches use the curriculum when they work with teachers). Classroom walkthroughs, a participation structure that is sometimes a component of infrastructures, has a designed aspect (the plan for the purpose and processes of meeting together and observing instruction) and a performative aspect (what participants actually noticed and discussed). All of this points to the duality of infrastructure and coaching. In this view, district infrastructures do not determine the actions and interactions of coaches. At the same time, coaches do not practice in a vacuum; they work within schools and districts and with and through infrastructure components that both enable and constrain their activity.

To summarize, coaching practice involves three essential constituting elements—coaches, others, and the infrastructure (in this case the infrastructure for elementary mathematics - see Figure 1). Coaching practice does not reside in any one of these elements, and each is a pre-requisite for coaching practice. My strategy for "seeing" coaching practice is through the interactions between coaches and other role groups. These interactions are mediated by the designed infrastructure for elementary mathematics. I will "see" coaching practice as coaches act through and with infrastructure components in their interactions. In this way, coaching is conceptualized as "stretched over" the broader educational infrastructures that includes other instructional leaders, structures, resources, and tools that together as a unit work to coordinate, maintain, and improve instruction.

Figure 1. Constituting elements of coaching practice



Dimensions of Infrastructure

The distributed perspective stresses the importance of the situation in practice. In this dissertation I have defined the situation as the district infrastructure for elementary mathematics. Research on infrastructure suggests that formal roles, structures, resources, and tools are more than "rituals or reifications" that have little influence on practice (Meyer & Rowan, 1977). But this begs the question: What are the dimensions of infrastructure that are likely to shape practice? Although the evidence base on infrastructure is nascent (Cohen & Moffitt, 2009; Peurach, 2011), a review of the literature highlights four dimensions that are potentially important for coaching practice: specificity, alignment, authority, and inclusivity (Cohen & Spillane, 1992; Cohen et al., 2013; Spillane, 2015; Stein & Coburn, 2008). Most of this research is from the policy implementation literature that is foremost concerned with whether and how policy influences teaching practice and student learning. Very little, if anything, is known about how these dimensions may influence coaching practice. Therefore, in the following sections I make some propositions about the relationship between infrastructure and coaching practice, drawing on the policy implementation literature when needed.

Specificity. I define specificity as *the degree to which the infrastructure provides clear and detailed guidance about what to teach and how to teach it.* Research suggests that some systems provide clear and detailed guidance about content coverage or pedagogy—such as standards, curricular materials, instructional frameworks, and assessments—while in other systems the guidance is general, vague, or non-existent (Cohen & Spillane, 1992). Some level of specificity has generally been accepted as a worthwhile thing, such as goals for student learning that have emerged from the standards movement. At the same time, research has not converged on what level of specificity matters for a strong instructional guidance system. For example, Stein & Coburn (2008) found that mathematics curriculum that was too specified hampered teachers' opportunities to learn. Specificity may also matter differently depending on the experience level of teachers. For example, new teachers may need more specified guidance initially, but with experience, they might gain the necessary skillset that makes working within an overly specified system burdensome.

I propose that coaching practice will likely look different depending on how specified the infrastructure is within which they work. In a system with higher specificity coaches have a clearer roadmap when working with school leaders and teachers and may be more likely to interact around shared resources and tools and to talk about similar practices and goals for student learning. At the same time, infrastructure that front loads a heavy dose of specificity may lead to coaches' interactions being more about figuring out the "right way to do it" and how to use the instructional materials or how to coordinate the standards, curriculum, and assessments. In other words, an overly specified infrastructure does not leave open room for

coaches and others to negotiate meaning and potentially redesign for the particular context in which they are confronted (Wenger, 1998).

Alignment. Alignment refers to the connections between components of the infrastructure such as standards, instructional materials, and professional development (Cohen & Spillane, 1992; Newmann et al., 2001; Bryk et al., 2010). I define alignment as *the degree to which there are coherent connections among different components of the infrastructure.* Although there are a range of terms that scholars have used to capture this idea (e.g., consistency, coherence, horizontal alignment, instructional program coherence), the central premise is the same; that is, strong infrastructures align and cohere around explicit goals for students' mathematical learning and a clear vision of mathematics instruction (Cobb & Jackson, 2011; Cobb et al., 2018; Newmann et al., 2001). The theory is that by aligning different elements of instructional policy, teachers will receive clear and consistent messages about how to focus and deliver instruction, as well as the materials and professional learning opportunities to do so. Indeed, an accumulation of research has found that policy alignment is associated with teachers' instruction that is aligned with shifts called for in the policy as well as student achievement in both mathematics and ELA (Polikoff, 2012; Newmann et al., 2001; Youngs et al., 2011).

I propose that coaching practice will likely look different depending on the degree to which the system within which coaches work is aligned. In an infrastructure with less alignment among its components, one can imagine coaches being pulled in multiple, conflicting directions if their roles and responsibilities are not well integrated with other improvement levers. One

can also imagine coaches in systems with low alignment spending a lot of time helping teachers and school leaders navigate mis-aligned policies.

Authority. I define authority as *the degree to which the infrastructure is designed to monitor or hold school leaders and teachers accountable to the district's student learning goals and instructional vision in mathematics.* The dimension of authority highlights the ways guidance for instruction is presented, from suggestions based on best practices to mandates for compliance. The infrastructure can also be set up in different ways to monitor the uptake of suggestions or mandates (Cohen & Spillane, 1992; Spillane, 2015). An accumulation of research suggests that infrastructures with strong accountability or monitoring mechanisms are likely to encourage a degree of classroom change but there is also the potential that the change is superficial or may be accompanied by increased resistance (Achinstein & Ogawa, 2006; Heilig & Darling-Hammond, 2008).

I propose that coaching practice will likely look different depending on the degree of authority the infrastructure within which they practice holds. For example, the degree of authority will likely shape the degree to which coaches have access to schools to work with school leaders and teachers, and the degree to which the selection of schools they work with are based on metrics the district monitors. The degree of authority may also shape the degree to which coaches are used as a monitoring arm of the district and hence interact with teachers for evaluative or data gathering purposes as opposed to learning purposes. Even if coaches are working with school leaders or teachers for learning purposes, one can imagine in a district with high authority that the focus of those interactions would more likely be around the district-

promoted reform agenda as opposed to the particular needs of individual teachers or schools. Further, the focus of these interactions may be more likely to be about superficial teaching practices because these are the practices that are most easily monitored for compliance.

Inclusivity. Finally, I define inclusivity as *the degree to which the infrastructure provides routinized opportunities for interaction between different role groups on issues of mathematics.* These opportunities for interaction may include meetings or trainings between principals and their supervisors or professional learning sessions for teachers facilitated by district math coaches. The key characteristic is that these opportunities occur regularly and bring staff from across the district together to interact and learn about issues of mathematics teaching and learning (Stein & Coburn, 2008). Research on organizational routines is informative here. Routines can structure day-to-day practice as they frame and focus interactions among staff (Spillane, Shirrell, & Hopkins, 2016). School and district routines have been found to help leaders standardize their instructional program, set and maintain direction, and monitor progress (Spillane, Parise, & Sherer, 2011; Sherer & Spillane, 2010).

I propose that coaching practice will likely look different depending on the degree to which the infrastructure provides opportunities for different role groups to interact about mathematics. The degree of inclusivity may shape coaches' abilities to find time and space to interact with other role groups about mathematics across the district. Coaches' ability to interact with other role groups has implications for their ability to broadcast the district vision for mathematics teaching and learning. Broadcasting allows everyone to get on the same page regarding what the district believes to be high-quality mathematics instruction and learning.

Variation in these four dimensions across the two school districts in this dissertation created an opportunity to systematically investigate how infrastructure design shapes coaching practice. I also follow Coburn and colleagues (2016) and investigate the intertwined nature of these dimensions, for example, how the practice of coaching is shaped by working within a system with high authority and high alignment versus a system with low authority and low alignment.

Chapter 4
Methodological Approach

To study the relationship between infrastructure for elementary mathematics and coaching practice, I drew on and extended data that was collected as part of a Heising-Simons Foundation funded study (henceforth referred to as the COHERE study). The COHERE study was a longitudinal, multi-level (district, school, classroom, student) study of two school districts' efforts to create policy alignment and instructional continuity between pre-kindergarten and grades K–3 mathematics.

Sample: Districts and Coaches

The research setting for this dissertation was two California school districts—Almond Valley Unified and Cypress Unified. Almond Valley is one of the largest districts in the state, serving more than 70,000 preK-12 students. Nearly half of the city's children live in poverty and 90 percent of the students in Almond Valley qualify for free or reduced-price lunch. The district serves a predominantly Latino population; nearly 70 percent of students are Latino, followed by Asian American, White, and African American. Historically, the students in Almond Valley have performed below the state average in mathematics. In 2018–2019, only 22 percent of students (Grades 3–8 and Grade 11) met or exceeded standards on the math Smarter Balanced Assessment (SBAC), compared to 37 percent statewide (California Department of Education, 2018).

Cypress serves just over 50,000 preK-12 students. The district also has a diverse student population. The largest ethnic group is Asian, but Latinos are close behind followed by White, African American, Filipino, and students who identify as multi-racial. Just over 50 percent of

students qualify for free and reduced-price lunch. Cypress has a history of performing at or above state averages in mathematics. In the 2018–2019 school year, 50 percent of students (Grades 3–8 and Grade 11) met or exceeded the standards in SBAC. However, in spite of strong averages, the district struggles to support African American and Latinx students in reaching proficiency in mathematics. Only 14 percent of African Americans and 25 percent of Latinx were proficient in mathematics that year (California Department of Education, 2018).

These two districts were selected for the COHERE study, but they were also strong candidates for my dissertation's research questions for four reasons: 1) both districts had adopted the CCSS-M and were working to support their teachers in making the instructional shifts called for in the standards, 2) both districts had designed and were working to implement an infrastructure for elementary mathematics teaching and learning, 3) coaching was an integral component of both infrastructures, and 4) the infrastructures had key variations in their designs. This last point was especially important because my study design depended, at least in part, on these variations for explanatory power.

Regarding coaching, both districts had mathematics coaches that were full-time, content specialists in mathematics, and were organizationally situated off-site (i.e., not tethered to schools) within each district's mathematics department. Coaches in both districts occupied a unique organizational position; on the one hand, coaches worked at the district level on issues of capacity building like developing instructional resources, planning teacher professional learning sessions, and looking at data to inform site support decisions. They also worked at the school level with individual teachers, groups of teachers, or school leaders on

instructional improvement tasks. This work included things like co-teaching or modeling, facilitating professional learning sessions, or helping school leaders think holistically about mathematics instructional improvement in their schools.

During the year of this study (2018-19 school year), Almond Valley had six elementary mathematics coaches and Cypress had five. For this dissertation, I sampled two elementary mathematics coaches from each district (see Table 1 below for demographics). These four coaches were selected because they were assigned to COHERE focus schools, thereby—theoretically—allowing me to use project data to contextualize coaching practice.[1] All of the focal coaches had been mathematics coaches in their respective districts for at least three years.

Table 1: Demographic characteristics of focal coaches

District	Coach	Gender	Race/ethnicity	Years as coach in district
Almond Valley	Tallulah	Female	Asian American	4
	Laverne	Female	White	3
Cypress	Olaf	Male	White	3
	Liza	Female	Middle Eastern	3

Data Sources and Collection Procedures

To understand the design of district infrastructures for elementary mathematics, how they may vary, and the role of the coach, I drew on district- and school-level interviews and district artifacts that were collected as part of the COHERE study. Across both sites, district leaders in the mathematics (including coaches) and leadership departments[2] were interviewed

[1] Ultimately, this did not work out because the coaches did not go to the focus schools during the times that I shadowed them.

[2] The leadership department is composed of top-level district administrators (i.e., superintendents and assistant superintendents) whose primary responsibilities are to supervise and support all schools in the system. A key

once during the 2018-19 school year (see Table 2 for counts). In general, district level interviews focused on leaders' roles and responsibilities, district priorities for mathematics instruction, how the district communicated priorities and provided supports for teachers in mathematics, data use related to mathematics instruction, and district efforts to foster alignment and coherence in mathematics teaching and learning.

School leaders[3] from three focal elementary schools in both districts were interviewed twice during the 2018-19 school year, once in the fall and once in the spring (see Table 2 for counts). Fall interviews focused on school leaders' roles and responsibilities, priorities for mathematics, and plans for mathematics professional development in their school. Spring interviews focused on how school leaders believed their plans for mathematics teaching and learning played out over the course of the year as well as how they interfaced with the district office, including the messages and supports school leaders received from district leaders in the leadership and mathematics departments.

component of their job is to oversee, evaluate, and provide professional learning opportunities for principals and assistant principals in the district. The mathematics department is part of Curriculum & Instruction (C&I) and houses the Chief Academic Officer (CAO), the Director of Mathematics or Math Manager, and their support staff, as well as mathematics coaches. The mathematics department's primary responsibility is to ensure that every child has access to high-quality mathematics teaching and learning in every classroom in the district. They do this by supporting curriculum and instructional strategy development and by providing professional development for teachers across the district.

[3] School leaders included principals, assistant principals, and school-based coaches.

Table 2. Number of interviewed participants and number of interviews completed by district

District	District Leaders	School Leaders
Cypress	15 (15)	8 (16)
Almond Valley	8 (8)	9 (18)
Total	23 (23)	17 (34)

Note: The first number in each cell represents the number of interviewed participants and the number in parentheses represents the number of interviews completed.

Two members of the COHERE research team and I conducted these interviews. We used semi-structured district and school interview protocols were used to ensure that comparable data were collected between interviewers and across respondents, however we were also careful to tailor the protocols based on the interviewee's role. Interviews lasted approximately 45-60 minutes and were audio-recorded and professionally transcribed.

To investigate how coaches enacted their roles, I observed two mathematics coaches from each district. Keeping the number of cases small was important because the depth of observation necessary to capture coaching practice required extensive fieldwork. I observed each coach during one observation window in winter 2019 and one observation window in spring 2019. Each window was comprised of approximately three consecutive days of observations followed by a debrief interview with the coach. Observing coaches for multiple days in a row provided insight into the flow and continuity of their work and scheduling my observations at two different times of the school year allowed insight into how the nature of their work might change as the immediate needs of the district shifted (e.g., SBAC testing at the end of the year). I worked with coaches to schedule observations that fell during a typical week of work, although I also recognized that the nature of coaching is variable and unanticipated

events frequently occurred. I observed coaches in Almond Valley for a total of 39.25 hours and coaches in Cypress for a total of 41.75 hours for a total of 81 hours of total observations across both districts (see Table 3).

Table 3. Hours observing coaches in each district by observation window

District	Coach	Winter	Spring	Total
Almond Valley	Laverne	10.12	9.17	19.29
	Tallulah	9.13	10.83	19.96
	Total	19.25	20	39.25
Cypress	Liza	10.08	11.58	21.66
	Olaf	9.92	10.17	20.09
	Total	20	21.75	41.75

To observe coaches, I used the 'shadowing' method. Shadowing is a type of observation technique that involved following the focal coach over an extended period while simultaneously recording an almost continuous set of field notes (McDonald, 2005; Bartkowiak-Theron & Sappey, 2012; Mintzberg, 1970, 1973). Shadowing is itinerant in nature which means I followed coaches around from the start of the workday until the end rather than observing the time periods that the coach considered "coaching." If the coach went to a meeting, I followed. If the coach ate lunch with colleagues, I joined. Additionally, I took an active role rather than the role of a passive third-party observer. This meant that I probed coaches for why they said or did certain things. To do this, I made sure to "exploit down times (such as travel to and from locations and walks between buildings) to immediately ask questions and seek explanations and/or interpretations from the shadowed participant" (Bartkowiak-Theron & Sappey, 2012, p.8).

The nature of the shadowing technique allowed me to view things that were important to my research questions. First, by shadowing coaches I was able to see all the people they interact with and the roles they each play in the overall system of instructional support in mathematics. This was important in light of my conceptualization of coaching as distributed across many instructional leaders, both formal and informal. Second, in addition to formal interactions (e.g., department meetings), I was able to see coaches' ad hoc and informal interactions that research suggests are so central to their work. Third, I was able to see them engage in and with other components of the infrastructure. For example, I saw them facilitate teacher professional learning, participate in department meetings, and support school leaders as well as engage with resources like instructional frameworks, curricular materials, and assessment data.

To extend the data collected by shadowing coaches, I also conducted debrief interviews after each observation window (winter and spring). These 45-minute, semi-structured interviews focused on 1) the purpose or goal of particular coaching activities, 2) coaches' use or participation in components of the district's mathematics infrastructure, 3) coaches' opinions or perspectives on particular coaching activities, and 4) the effect, if any, my presence had on their work. Debrief interviews were audio-recorded and professionally transcribed.

Data Analysis

I conducted three analyses, each aligned with one of my three research questions (see Table 4).

Table 4. Data sources analyzed for each research question

Research question	Data sources for analysis
1. What is the design of infrastructures for elementary mathematics in two school districts?	District leader interviews; school leader interviews; artifacts
2. How do coaches enact their role in these different infrastructure designs?	Field notes from observations of coaches; debrief interviews with coaches
3. How do variations in district infrastructures for elementary mathematics shape coaching practice?	District leader interviews; school leader interviews; artifacts; field notes from observations of coaches; debrief interviews with coaches

Research Question 1: What is the design of infrastructures for elementary mathematics in two school districts?

To identify the component parts of each district's infrastructure for elementary mathematics, I analyzed interviews with district and school leaders for instances when they talked about roles, structures or routines, and resources, materials, or tools they designed to guide, support, or improve elementary mathematics instruction across the district. I approached the data with a priori codes guided by Cobb and colleague's (2018) framework that outlines infrastructure components that matter for instructional improvement at scale. Given that these two districts claimed to be working on instructional improvement at scale, one would expect to see the infrastructure components identified by Cobb et al (2018). These are: 1) student learning goals, 2) instructional framework, 3) instructional materials, 4) assessments, and 5) teacher learning (which included the sub-codes of pull-out professional learning, coaching, and teacher collaborative time). To these I added a sixth: school leader learning (see Table 5 below for definitions of all infrastructure components). While these codes guided my analysis, I also allowed for other key components to be revealed inductively from the data.

During this analysis I also paid particular attention to the design of coaching and the role coaches were designed to play in the overall infrastructure.

Table 5. Definitions for key infrastructure components

	Definition
Student Learning Goals	A set of values regarding what is worth knowing and doing mathematically.
Instructional Framework	Specifies what should happen between teachers and students in order to achieve the student learning goals.
Instructional Materials	Adopted or system-developed curriculum as well as district-developed resources such as curriculum frameworks and pacing guides.
Assessments	Summative or formative evaluations of student progress towards specified learning goals.
School Leader Learning	Supports for school leaders or ways in which school leaders were mobilized to improve the quality of mathematics instruction in their school.
Teacher Learning	Supports for teachers to learn to implement mathematics instructional practices that align with the instructional framework.
Pull-Out PL	Professional learning in which teachers from multiple schools engage, usually, but not necessarily, by grade level.
Coaching	Professional learning from a person with content-specific expertise in mathematics to support teachers (1-on-1 or with a small group) to improve the quality of their instruction.
Collaborative Time	The various ways that teachers gather with colleagues.

To analyze for how the infrastructure designs varied, I analyzed each district's infrastructure for elementary mathematics along four dimensions: 1) inclusivity, 2) authority, 3) specificity, and 4) alignment. I selected these dimensions through a deductive approach, that is, these are the dimensions along which infrastructures may vary and that the literature suggests are likely to matter for school and district practice. I also left open the possibility that I would find other dimensions along which these two districts differed. In the sections that follow, I describe how I analyzed data for each dimension, including the criteria by which I designated each dimension as low, medium, or high (see Table 22 in Appendix A for full list of definitions).

Inclusivity

I defined inclusivity as the degree to which the infrastructure provides routinized opportunities for interaction between different role groups on issues of mathematics. To analyze each district's infrastructure for inclusivity, I reviewed interviews with individuals in the district math department, the leadership department, and school leaders to find instances where they talked about recurring meetings, professional development or coaching sessions, or other routinized ways of interfacing with individuals outside their own role group on issues of mathematics. Because I was particularly interested in the formal opportunities for interaction between the district math coaches and other role groups, I designated low, medium, and high inclusivity based on the extent to which the infrastructure provided district math coaches with opportunities to meet with different role groups. More specifically, I considered a district's infrastructure to have high inclusivity if there was at least one routinized opportunity for interaction between math coaches and three or more different role groups. I considered a district's infrastructure to have medium inclusivity if there was at least one routinized opportunity for interaction between math coaches and two other role groups. I considered a district's infrastructure to have low inclusivity if there was at least one routinized opportunity with one or fewer other role groups.

Authority

I defined authority as the degree to which the infrastructure is used to monitor or hold school leaders and teachers accountable to the district's student learning goals and instructional framework. To analyze each district's infrastructure for authority, I reviewed

interviews with district leaders from the district math department and administrators who oversaw principals for information about the following:

1. District mandates relating to school leader practices, teacher instructional practices, or student learning
2. Data collected pertaining to student learning goals
3. Data collected pertaining to teachers' mathematics instruction
4. How these data were used, if at all
5. District leaders' perceptions about whether school leaders and teachers take the infrastructure seriously or engage earnestly with its guidance

I also reviewed interviews with school leaders for whether district leaders' perceptions about them and their relationship with the district infrastructure tracked.

I considered a district's infrastructure to have high authority if there were district mandates accompanied by high accountability. High accountability is defined as consistent accountability in two or more spheres of activity (e.g., instructional practices). I considered a district's infrastructure to have medium authority if there were district mandates accompanied by moderate accountability. Moderate accountability is defined as accountability in at least one sphere of activity (e.g., instructional practices) or accountability that waxes and wanes over the school year. I considered a district's infrastructure to have low authority if there was complete or near complete autonomy on the part of teachers and/or school leaders. This included a lack of district mandates and mechanisms of accountability.

Specificity

I defined specificity as the degree to which the infrastructure provides clear and detailed guidance about what to teach and how to teach it. To analyze each district's infrastructure for specificity, I focused on the reified resources in each district's design that supported teachers and school leaders as they navigated what to teach in elementary mathematics and how to teach it. I focused my analysis on these reifications because they provided a "point of focus" around which different role groups worked. By their very nature they "held steady" ideas and processes across time and space.

In Almond Valley I focused my analysis on four key resources designed by the district to guide and support what to teach and how: the Instructional Practice Guide (IPG) (the district's instructional framework in mathematics), the *Go Math* curriculum (Harcourt, Houghton Mifflin, 2015), the Quarterly Planner (a resource designed by Almond Valley's mathematics department that provided guidance to teachers regarding how to productively utilize the *Go Math* curriculum with their students), and the interim assessments. In Cypress I focused my analysis on three resources: the Core Curriculum (the district-designed mathematics curriculum), the Math Teaching Toolkit (a resource designed by Cypress's mathematics department intended to support teachers in their use of the Core Curriculum), and the interim assessments. I analyzed across these six resources for the degree to which they specified what to teach, including 1) content, 2) learning goal(s), and 3) route to reach learning goals of the lesson. I also analyzed across them for whether they specified how to teach, including 1) pacing and sequencing, 2)

timing of different parts of a lesson, 3) models, representations, and tools to use or have available for students to self-select, and 4) core instructional practices in mathematics.

For my analysis of each district's curriculum, I did not analyze the entirety. Instead, I randomly selected a lesson from kindergarten, 1st, and 2nd grades in Almond Valley (that attended to different standards) and then found lessons in those grades levels in Cypress that focused on the same standard(s)[4] (see Table 6 for the lessons I analyzed). I focused my curricular analysis only on what the teacher saw when looking at these lessons and did not include an analysis of any curricular front matter. I ensured that random selection of lessons would not skew findings by reviewing the entirety of each curriculum to confirm that lessons followed a similar format within and across grades. Thus, it was very likely that I would find similar attributes in each lesson.

Table 6. Lessons analyzed from curriculum in each district by grade and standard

Grade	**CCSS-M**	**Almond Valley**	**Cypress**
Kindergarten	K.CC.6. Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group, e.g., by using matching and counting strategies.	Lesson 2.2	Unit K.2: Lesson Series 3, Day 1
1st	1.MD.4. Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.	Lesson 10.4	Unit 1.10: Lesson Series 3, Day 1 & 2
2nd	2.NBT.5. Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the	Lesson 4.3	Unit 2.3: Lesson Series 1, Day 2

[4] Lessons were selected from these grades (as opposed to 3rd, 4th, 5th, or 6th) because these were the grade levels of the *Go Math* curriculum I had access to.

	relationship between addition and subtraction.		

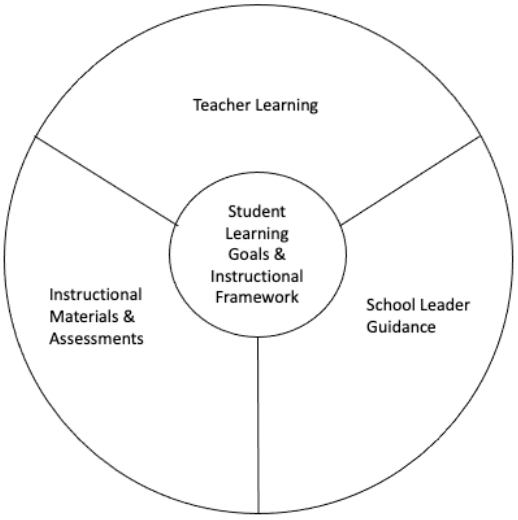
I considered a district's infrastructure to have high specificity if all four of the following were clear and detailed: content, learning goals, route to reach the learning goals, and core instructional practices. Also at least one of the following: pacing and sequencing, timing of different parts of a lesson, models, representations, and tools to use or have available for students to self-select. I considered a district's infrastructure to have medium specificity if two or three of the following were clear and detailed: content, learning goals, route to reach the learning goals, and core instructional practices. Also at least one of the following: pacing and sequencing, timing of different parts of a lesson, models, representations, and tools to use or have available for students to self-select. I considered a district's infrastructure to have low specificity if one or none of the following were clear and detailed: content, learning goals, route to reach the learning goals, and core instructional practices.

Alignment

I defined alignment as the degree to which there are coherent connections between different components of the infrastructure and the student learning goals or instructional framework. The theory is that by aligning different components of instructional policy, district and school professionals will receive clear and consistent messages about how to focus and deliver instruction, as well as the materials and professional learning opportunities to do so. To analyze each district's infrastructure for alignment, I adapted Cobb and colleague's (2018) systemic perspective on teaching and learning to anchor my analysis. As portrayed in Figure 2, Cobb and his colleagues conceptualize student learning goals and the instructional framework

at the center of the infrastructure. They argue that it is essential that the remaining elements of the infrastructure (teacher and school leader learning and instructional materials & assessments) are aligned with the student learning goals and associated instructional framework if they are to support teachers' development of instructional practices that enable all students to attain rigorous learning goals.

Figure 2. Systemic perspective on teaching and learning



In Almond Valley, the CCSS-M served as the student learning goals and the IPG served as the instructional framework (comprising the middle of Figure 2). Cypress did not have a detailed instructional framework with subject- or grade-specific rubrics akin to the IPG in Almond Valley. The main document that set out the instructional vision for the district was the district's strategic plan. However, the instructional vision in that document was content neutral and quite general. It laid out three broad dimensions of teaching and learning: 1) agency, authority, and identity; 2) access to content; and 3) use of formative assessment to guide instruction.

Given the general nature of the instructional framework embodied in the strategic plan, mathematics leaders in the district turned instead to the CCSS-M and Math Practices, using them to guide curriculum development and professional learning opportunities. Therefore, I considered the center of Figure 2 for Cypress to be the CCSS-M (covering both the student learning goals and instructional framework). In the following sections, I describe how I analyzed each component of the infrastructure for alignment to either the CCSS-M or the IPG[5]. Because each component of the infrastructure is different, I used different criteria by which I designated each component as having low, medium, or high alignment.

Instructional Materials & Assessments. For instructional materials, I focused my analysis on the alignment between each district's curriculum and the CCSS-M. Here I was interested in the degree to which each curricula focused on the knowledge and skills called for in the standards. To do this, I drew on and extended an in-depth curriculum analysis conducted by members of the broader COHERE research team (McMahon & Whyte, 2020; Coburn et al., 2018). To assess alignment in each district's curricula, we first identified all units related to number and number operations[6]. We then coded curriculum activities for both content and cognitive demand. Content refers to the topics covered in the specified curriculum activity. We used a set of topics that were derived from the California Common Core Learning Standards for

[5] Because Almond Valley had adopted student learning goals (CCSS-M) and an instructional framework (IPG), sometimes infrastructure components were compared against the CCSS-M (e.g., curriculum) and sometimes they were compared against the instructional framework (e.g., school leader learning and teacher learning). In Cypress, everything was compared against the CCSS-M.

[6] We chose to focus on number and number operations because these areas of mathematics have been found to have a predictive relationship with students' early number competence and math achievement through grade 3 (Jordan et al., 2009).

Math as our content codes. Any given activity could have multiple content topics, and would therefore, receive multiple content codes. Cognitive demand refers to the level of challenge a student would encounter when they tried to complete a task. We drew on Webb's Depth of Knowledge to measure cognitive demand (Webb, 1999; Webb et al., 2005). Webb identifies four levels of cognitive demand: 1) Recall or reproduction, 2) application of concepts, 3) strategic thinking, and 4) extended thinking (see Table 23 in Appendix B for definitions of levels of cognitive demand). When we couldn't determine the challenge presented in a task, we indicated that there was "not enough information," or NEI. Multiple coders with an interrater reliability of .89 applied content and cognitive demand codes to the curricula.

To determine each curriculum's level of alignment in content with the CCSS-M, we analyzed the degree to which there was content that covered each of the grade-level standards. Because there is an expectation that the curricula covers all the relevant standards for each grade, we used a high bar for alignment between curricula and the standards. We judged the curricula to have high alignment only if all standards were covered. We judged the curricula to have medium alignment if 80% - 99% of the standards were covered. We judged the curricula to have low alignment if 79% or below standards were covered. We rooted our assessment of alignment in cognitive demand in the fact the CCSS-M are designed so that students have the opportunity to engage in learning activities that have a range of cognitive demand in a given grade level. This design implies that an ideal situation would involve a mix of levels of cognitive demand in all grades so that students have the opportunity to engage in procedural review plus analysis and extending. Thus, we deemed a given grade level to have

high alignment in cognitive demand if it had a balance of three out of the four levels of cognitive demand. We deemed a given grade level to have medium alignment in cognitive demand if it had a balance of two out of the four levels of cognitive demand. We deemed a given grade level to have low alignment in cognitive demand if they do not include activities at one or more of the levels.

Because in an aligned system, the assessments should be linked to and cover the material in the curricula, we used the same codes to assess alignment of content and cognitive demand between the assessments and the curricula. To assess alignment of content, we reasoned that one would not expect assessments to include all the content covered in a curriculum. Instead, we identified those topics in the curriculum that were most salient in each grade level, which was, in this case, the content that appeared in more than 25 activities. To assess alignment in content, we then calculated how many of these topics at a given grade level appeared on the assessment for that grade level. We considered assessments to have high alignment in content with the curriculum if the overlap between topics covered by the assessment and the curriculum was at least 75 percent. If there was between 50 percent and 75 percent overlap then we considered them to have medium alignment, and if there was less than 50 percent overlap than we considered them to have low alignment in content.

To assess alignment of cognitive demand between assessments and the curriculum, we compared the percentage of different levels of cognitive demand in the curriculum units with those levels in the assessments in a given grade level. We considered assessments to have high alignment in cognitive demand with the curriculum if the percentages of three out of the four

levels of cognitive demand were within 10 percentage points of each other (e.g., 20 percent of items on the assessment were level one compared to 13 percent of items in the curriculum, 33 percent were level two compared to 28, etc.). We considered assessments to have medium alignment in cognitive demand with the curriculum if the percentages of three out of the four levels of cognitive demand were within 10-20 percentage points of each other. We considered assessments to have low alignment in cognitive demand with the curriculum if the percentages of three out of the four levels of cognitive demand were greater than 20 percentage points from each other.

School Leader Learning. To determine alignment between school leader learning opportunities and the instructional framework (IPG in Almond Valley and CCSS-M in Cypress), I analyzed the degree to which the school leaders' learning experience focused on mathematics and the degree to which the instructional framework played a role in the experience. I considered school leader learning to have high alignment with the instructional framework when issues of mathematics teaching and learning had high priority and when there was a consistent focus on the core instructional practices called for in the instructional framework. I considered school leader learning to have medium alignment with the instructional framework when there was a moderate focus on mathematics and the core instructional practice called for in the instructional framework. I considered school leader learning to have low alignment with the instructional framework when there was a lack of focus on mathematics or when the focus was on general instructional strategies absent specific references to content (e.g., how to give advice to teachers).

Teacher Learning. To determine the alignment between teacher learning and the instructional framework, I analyzed the degree to which these professional development instances promoted pedagogical strategies consistent with the instructional framework in Almond Valley, and the high priority pedagogical strategies aligned with the standards in Cypress. I considered teacher learning to have high alignment with the instructional framework when there as a strong focus on mathematics and a consistent focus on the core instructional practices called for in the standards. I considered school leader learning to have medium alignment with the instructional framework when there was a moderate focus on mathematics and when there was a moderate focus on the core instructional practices called for in the standards. I considered school leader learning to have low alignment with the instructional framework when there was a lack of focus on mathematics or when the focus was on general instructional strategies absent specific references to content (e.g., how to structure the lesson to better differentiate instruction).

To review, for research question 1 (What is the design of infrastructures for elementary mathematics in two school districts?), I analyzed interviews to determine the key components of each district's infrastructure for elementary mathematics and then analyzed these infrastructures along four dimensions: inclusivity, authority, specificity, and alignment. Table 22 in Appendix A lists the dimensions, levels, and corresponding definitions for readers to refer to for reference.

Research Question 2: How do coaches enact their role in these different infrastructure designs?

To investigate how coaches enacted their role, I utilized my field notes from observations of Laverne and Tallulah in Almond Valley and Liza and Olaf in Cypress. My unit of analysis for coaching practice was what I called a *coaching task.* I defined a coaching task as a coherent set of activities aimed at supporting teacher learning or the conditions that support teacher learning (e.g., school leader learning and support). To segment my data into coaching tasks, I read through all my field notes to identify when one task ended and another one began. I approached this coding with a priori codes that the coaching literature suggests figure prominently in coaches' practice such as observing and debriefing teachers' instruction, planning and facilitating teacher professional learning, and district level capacity building tasks. I also left open the possibility that the coaches may have engaged in novel coaching tasks not found in the literature. In total I observed 30 coaching tasks in Almond Valley and 31 in Cypress. The length of tasks ranged from 20 minutes to over 200 minutes.

After segmenting my field notes by coaching tasks, I coded each individual task for the following: length, location, who participated, why the task was undertaken, whether the task was an enactment of a designed structure, and whether a designed resource was used and if so, how.

After this, I identified interactions that comprised each task. I defined an interaction as talk between a coach and someone else that revolved around a singular focus. There could be several interactions nested within a single task. To code for the focus of interaction, I used a

coding scheme that I developed through systematic, iterative coding (Miles, Huberman, Saldana, 2019). I began with codes that described, with little interpretation, the focus of interaction. I grouped together categories using the constant comparative method (Strauss & Corbin, 1990) until I ended up with a final set of codes, including instructional strategies, superficial features of classroom instruction, student thinking and learning, and how to use or coordinate instructional materials among others (see Appendix C for complete list of focus codes and their definitions). In total, I analyzed a total of 271 interactions for which I had enough information to assess the focus.

Research Question 3: How do variations in district infrastructures for elementary mathematics shape coaching practice?

I developed my answers to this question through an iterative back-and-forth process between what I knew about each district's infrastructure (Chapters 5 and 6) and what I knew about coaching practices in each district (Chapter 7). More specifically, I exploited the *differences* across the two districts in terms of their infrastructure dimensions and in terms of their coaching practices. For example, I knew (from my cross-case comparison) that Almond Valley coaches more frequently used common district math resources than did Cypress coaches. Based on what I knew about each district's infrastructure I developed "mini conjectures" for what dimension or combination of dimensions might be influencing this difference in coaching practices. Then I carefully combed through my data (interviews, observations, and artifacts) to see if there was evidence to support the conjecture or evidence that disconfirmed it.

Chapter 5
The Design of Infrastructures for Elementary Mathematics

Both Almond Valley and Cypress adopted a vision for students' mathematical learning that was aligned with the CCSS-M. District leaders wanted students to develop understanding of important mathematical concepts rather than memorize procedures they did not understand. Toward that end, district leaders wanted students to be able to solve and make sense of problems in multiple ways, to be able to justify their solution strategies, and to persevere when engaged in high cognitive demand tasks for which they have not been given an algorithm for solving. The goal was for students to be able to use multiple representations to think, reason, and problem solve.

Aligned with these goals for student learning, both districts promoted a vision of mathematics instruction that was aligned with the vision promoted by NCTM's *Principles to Action* (National Council of Teachers of Mathematics, 2014). They wanted to see teaching practices that utilized rigorous instructional tasks, that encouraged and supported students' sensemaking as they worked on these tasks (without taking over the thinking for the students), and that facilitated meaningful mathematical discourse among students. The goal was for teachers to elicit and make sense of student thinking and to orchestrate productive whole-class discussions that connected students' developing ideas to important mathematical ideas.

Each district also pursued specific improvement goals during the year of this dissertation study. Almond Valley was focused on three tenets in their instructional framework (i.e., the IPG): 1) rigor, that is, ensuring the lesson targeted conceptual understanding, procedural skill and fluency, and application called for in the standards, 2) ensuring the teacher made the

mathematics of the lesson explicit by using representations and tools, and 3) ensuring students engaged in academic discourse, such as asking questions about each other's thinking to clarify, self-assess and/or improve their own mathematical understanding. Cypress was equally focused on helping teachers to support academic discourse in their classrooms. Cypress was also targeting improvement of teachers' lesson summary. Below Olaf described what he meant when he said the district is working on "strong summaries":

> A strong ending to a lesson, a strong bringing everybody together and going, 'Okay, so what did we do today? What did we learn?' In my years of both being a classroom teacher and being a supporter, coach/privileged person who gets to go into other people's classrooms and see so many teachers teach, it's [the lesson summary] so hard. Everybody struggles with it.

Cypress was also focused on issues of race and equity during the 2018-19 school year. All staff in the Curriculum & Instruction department was engaged in a book study around Zaretta Hammond's *Culturally Responsive Teaching & the Brain* (Hammond, 2014). The math department was also engaged in their own internal racial equity work where they examined how they re-enacted white dominant culture and how that impacted their relationships in schools and with others in their own department.

To achieve these ambitious reforms, both districts engaged in the design and implementation of infrastructure intended to guide and support school leaders and teachers as they tried to improve elementary mathematics teaching. In this chapter, I describe the design of each district's infrastructure for elementary mathematics including, 1) formal roles, 2) resources, materials, or tools designed to carry the district vision for elementary mathematics

to different communities across the district, and 3) participation structures designed so individuals could learn about the district vision and how to improve mathematics instruction.

Almond Valley's Infrastructure for Elementary Mathematics

Roles

In Almond Valley, there were three role groups primarily responsible for mathematics: 1) district math coaches (and the elementary math manager that supervised them), 2) assistant superintendents, and 3) school leaders. District math coaches were math content-specialists. Their primary responsibility was to ensure children had access to high-quality mathematics teaching and learning in every classroom in the district. To accomplish this, they were tasked with providing professional learning opportunities, coaching, and other forms of support to school leaders and teachers. During the 2018-19 school year, Almond Valley had six, full-time elementary math coaches who worked at the district level within the district's mathematics department. They were not tethered to particular schools but instead dropped in on—or were dispatched—to a wide array of elementary schools across the district depending on need. Almond Valley's coaches were grade-level specific and only coached in mathematics (as opposed to being generalists who coached across content areas).

Assistant superintendents were top-level district leaders whose primary responsibility was to supervise and support a region of schools in the district. During the 2018-19 school year, Almond Valley had seven regions of elementary schools each supervised by one of two assistant superintendents. A key component of their job was to oversee, evaluate, and provide professional learning and guidance to principals and assistant principals.

By school leaders, I mean principals and assistant principals. Some schools also had school-based coaches, but according to Laverne, “Site-based coaches have a wide range of what they do. It’s based on what the site has them do because it comes out of site budget.” Because their role was determined at the site level, it was impossible to know how often they focused on mathematics, or anything specific about what they did, so I did not include them as a designed component of the district’s infrastructure for elementary mathematics.

Resources/Materials/Tools

Almond Valley designed several resources that embodied the district’s vision for mathematics. The cornerstone of these resources was the IPG. The IPG, developed by the non-partisan, non-profit organization Achieve the Core, was a document that laid out expectations for classroom practice consistent with the CCSS-M. It outlined the specific actions and behavioral indicators to look for to determine whether students are getting to the intent of the standards through the content of the lesson. It was designed as a developmental rubric that measured teaching based on five dimensions: classroom culture, lesson content, student engagement, access to content, and monitoring of student progress. As described in the math IPG, “The Instructional Practice Guide articulates the vision for skillful mathematics teaching and learning. The guide describes the core instructional practices that contribute to student learning. Uses include: 1) lesson preparation; 2) reflecting within PLCs on instructional practices contributing to student outcomes; 3) focusing professional learning on standards-aligned practice; 4) providing precise feedback/next steps on classroom practice” (IPG: Mathematics, 2018).

Almond Valley's infrastructure also included instructional materials: a mathematics curriculum and accompanying planner. The district adopted a commercial curriculum (Houghton Mifflin Harcourt's *Go Math*) in 2015 so at the time of this study the district was in its third year of implementation. *Go Math* is designed around the 5E lesson frame model which is meant to mimic the scientific inquiry process through progressive stages of Engage, Explore, Explain, Elaborate, and Evaluate. The other key instructional resource in Almond Valley was the Quarterly Planner. The Quarterly Planner was designed by the district's math department and provided guidance to teachers regarding how to productively utilize the *Go Math* curriculum with their students. More specifically, the Quarterly Planner specified for each curriculum chapter the big mathematical idea(s) at play, essential questions they will investigate, and the models/tools, materials, and strategies to be used in instruction. It also included the relevant standards and math practices, ways to engage students' prior knowledge, key academic vocabulary and supports for developing academic language, and math fluency.

Student assessments were another key resource in Almond Valley's infrastructure. Beginning in the first grade, Almond Valley administered interim assessments in mathematics three times per school year. These assessments consisted of multiple-choice items drawn from an item bank provided by an external company. District math leaders selected items that they viewed as linked to the most important standards covered during that time-period in the curriculum. Kindergarten students did not take the interims. Instead, they took the district-designed KinderAssess[7] near the beginning of the school year. Kindergarten teachers

[7] I used a pseudonym when referring to this assessment to protect the anonymity of the district.

administered the KinderAssess to students in a one-on-one setting. KinderAssess was used to assess a number of counting and cardinality skills (e.g., counting by ones and tens) as well as operations and algebraic thinking skills (e.g., finding the number that makes 10).

One final tool in Almond Valley that was a key component of the infrastructure was the 6-to-8 Week Plan. The 6-to-8 Week Plan was developed by principals with the support and guidance of their assistant superintendent. In the plan, principals had to: 1) identify a problem of practice, 2) describe the desired change(s) and expected evidence of the change(s), 3) describe the leadership moves they will make to achieve the desired change(s), and 4) describe how they will monitor progress towards the goals. All of this was planned for a six-to-eight-week period, at which point, principals started another plan for the next six to eight weeks. According to the assistant superintendents, the purpose of the 6-to-8 Week Plan was to "push principals to get specific about small, incremental, measurable improvements they could make in their teachers' instruction."

Participation Structures

To support the infrastructure's resources in use, Almond Valley also designed participation structures to facilitate interaction between different role groups as they used the resources to try to improve mathematics instruction across the district. Participation structures in Almond Valley included: 1) classroom walkthroughs, 2) Instructional Practice Walks (IPWs), 3) district instructional leadership team (ILT) meetings, 4) regional teacher professional learning, and 5) coaching assistance.

Regular classroom walkthroughs served as the core participation structure in Almond Valley. Classroom walkthroughs were designed to be enacted by staff who worked at various levels of the district, from school leaders to coaches and department heads to upper district leadership. The design of classroom walkthroughs involved a visit to a school during which members of the walkthrough team visited several classrooms to observe instruction, sometimes debriefing with the teacher afterwards. Walkthroughs used a rubric linked to the IPG to observe instruction. These data were then inputted into a district-wide system; the expectation was that they were used to understand what was working and how to better support schools in their math instructional improvement efforts. As part of the design of their role, district math coaches observed classrooms in one school per week with the IPG.

A special kind of classroom walkthrough was designed as the primary vehicle for school leader learning in Almond Valley: IPWs. IPWs were monthly meetings with small groups of school leaders (approx. 12-15), facilitated by an assistant superintendent. IPWs followed a similar routine each time. At the opening of every session the host principal talked about their school. Most principals presented their current 6-to-8 Week Plan. This plan oriented the other principals to what staff at the school was currently focused on improving and what to pay attention to during their classroom walkthroughs that happened later in the IPW. After the principal's presentation, the assistant superintendent led a 60-minute professional development around content that was relevant to what they were working on as a group and broader district. District leadership designed the learning with content-specialists when appropriate. During the 2018-19 school year, the vast majority of elementary IPWs were

focused on mathematics, which meant district mathematics coaches worked closely with district leadership to design these learning experiences. After the joint learning, everyone walked classrooms to observe instruction using the IPG as an observation tool, focusing specifically on what the principal introduced as the school's areas of focus at the start of the IPW and on what they learned about during their joint learning. Once everyone returned from observing classrooms, the assistant superintendent led a reflection and debrief based on what they observed in classrooms, including potential next steps.

Almond Valley also designed weekly district ILT meetings to bring together assistant superintendents and the managers from different departments in curriculum & instruction. One assistant superintendent described the weekly ILT meetings here:

> You sit at a big round table with each department head of those places - early learning, English learners department, special ed department, curriculum and instruction. It encompasses math and English language arts. We're all at the table together and we put up data of where there's big issues. We bring in the discussion a little bit of what we're seeing, but not as in the weeds, more like school-wide. Out of my 33 [schools], I'm noticing this. Here's my moves I made. Is the data backin' up what I'm saying? Do I need help from curriculum department?

Triston, the manager for elementary mathematics and supervisor of the district mathematics coaches, was present at these meetings every week.

Regarding teacher professional learning, Almond Valley was moving away from pull-out (i.e., not within the school or classroom context) professional learning sessions that research has shown are not typically a productive use of teachers' time. However, Almond Valley did still have one such opportunity during the 2018-19 school year: regional teacher professional learning. Regional professional learning was a year-long professional development offered to all

elementary teachers in one region of the district. This learning structure was designed because all the principals in one region got together with their assistant superintendent and decided that mathematics was a content-area they all wanted to focus on for the entire 2018-19 school year. Mathematics coaches then designed a year-long learning progression by grade-level and met 10 times across the school year for half-day trainings. These trainings closely followed where the teachers were at in the *Go Math* curriculum. During these trainings, teachers engaged in math tasks from the curriculum, learned about the key standards for each lesson, learned how to ensure their use of the curriculum met the standards, looked at student work, and got to talk and learn with teachers from other schools in their region.

Teachers were also supported through ongoing coaching assistance from district math coaches. Coaches typically assisted teachers in small-group (grade-level team) or whole-school settings due to the small number of mathematics coaches at the district level. The focus of this support was determined through student data as well as ongoing classroom walkthroughs and conversations between Triston (the elementary mathematics manager) and the mathematics coaches, school leaders, and assistant superintendents. Mathematics coaches also provided support to school leaders either through discussions during classroom walkthroughs or in one-on-one meetings.

Cypress's Infrastructure for Elementary Mathematics

Roles

Like Almond Valley, district math coaches, assistant superintendents, and school leaders were the primarily role groups responsible for mathematics in Cypress. Coaches in Cypress

were similarly content specialists in mathematics and organizationally situated at the district level. During the 2018-19 school year there were five, full-time district math coaches. Unlike Almond Valley, coaches in Cypress were not grade-level specific. Coaches' primary responsibility was to support schools and teachers as they tried to align their instruction with the instructional shifts called for in the CCSS-M. To do this they were tasked with facilitating teacher professional learning, coaching, and other forms of support to school leaders and teachers. Unlike Almond Valley, however, school level coaching was only provided to a select group of low resource, low achieving "focus schools" that were predetermined by the district. Each coach supported approximately three focus schools. Additionally, all district math coaches had to serve as induction coaches for up to two new teachers. This was an artifact of the high teacher turnover in Cypress.

Like Almond Valley, assistant superintendents in Cypress were top-level district leaders whose primary responsibility was to supervise and support a cohort of elementary schools in the district. During the 2018-19 school year, Cypress had seven cohorts of schools each supervised by an assistant superintendent. A key component of their job was to oversee, evaluate, and provide professional learning and guidance to principals and assistant principals. School leaders in Cypress consisted of principals, assistant principals, and school-based coaches. School-based coaches were in 42 of Cypress's chronically low-achieving schools and were paid for through district funds. Unlike school-based coaches in Almond Valley, these coaches specifically provided coaching around issues of curriculum and instruction. According to the supervisor of school-based coaches, these coaches were "…equity-focused teacher leaders at

the schools. Their work is to focus on closing the achievement gap…they do that through working with adults in the building, building professional capacity systems, which is teacher collaboration, professional development, coaching, and they have a really strong equity and data mindset in their work." Which content area school-based coaches focused on depended on individual negotiations between them and the school principal.

Resources/Materials/Tools

Cypress did not have an instructional framework or anything akin to the IPG in Almond Valley. Instead, all their improvement efforts were anchored around the curriculum and embedded "Signature Strategies." Rather than purchase a commercial curriculum linked to the CCSS-M, Cypress developed its own curriculum: the Core Curriculum. As of the year of this study, the district was in its fifth year of implementation. The Core Curriculum units were designed around four math tasks: Entry, Apprentice, Expert, and Milestone. In between each of the tasks were the lesson series. All tasks were intended to be used for formative assessment (i.e., gathering information about what students know and are able to do).

Embedded in the curriculum were three high-leverage "Signature Strategies": Math Talks, Three-Read Protocol, and Groupwork Feedback. A Math Talk is a pedagogical tool for building math thinking and academic discourse. In a Math Talk, the teacher presents a problem and students spend a minute or two solving the problem mentally. Then students share their answers, and the teacher asks questions to help students express themselves, understand each other, and clarify their thinking to make sense of the problem and its possible solution pathways. Three-Read Protocol is one way to do a close read of a complex mathematics word

problem or task. This pedagogical strategy includes reading a mathematics scenario three times with a different goal each time: (1) to understand the context, (2) to understand the mathematics, and (3) to elicit inquiry questions based on the scenario. Finally, Groupwork Feedback is a pedagogical strategy to publicly recognize the classroom's mathematical norms as students work in groups. During Groupwork Feedback, the teacher takes public notes about the quality of the group work and the quality of the math discussions.

Accompanying the Core Curriculum was the Math Teaching Toolkit. The Math Teaching Toolkit was a resource intended to support teachers in their use of the Core Curriculum. As Faith (the district's math manager) described, "While the Cypress Core Curriculum itself—the units built upon rich math tasks and formative assessments—is the what, this toolkit represents the how." There were three key components of the Math Teaching Toolkit. The first was a description of the three Signature Strategies described above. The second was classroom structures teachers could use to successfully implement the Core Curriculum, such as classroom norms, 5 Practices for Orchestrating Productive Mathematical Discussion, and gallery walks. The third was classroom tools teachers could utilize to such as math notebooks and technology tools.

Regarding student assessments in Cypress, all the tasks within the Core Curriculum (Entry, Apprentice, Expert, and Milestone) were intended to be used by teachers as formative assessments. Milestone assessments from two, pre-selected units served as interim assessments and were turned in to the district. These assessments were graded by teachers using a milestone calibration rubric supplied by the district.

Participation Structures

To support the infrastructure's resources in use, Cypress also designed participation structures to facilitate interaction between different role groups as they used the resources to try to improve mathematics instruction. Participation structures in Cypress included: 1) cohort meetings, 2) teacher leader trainings, 3) new teacher professional learning, 4) induction coaching, 5) Lesson Study, 6) school-based coach support, and 7) ongoing coaching assistance.

The primary structure for school principals to learn was monthly cohort meetings facilitated by assistant superintendents. The ways in which cohort meetings were run and the content they covered depended on the assistant superintendent, however a common learning structure was Instructional Rounds. Instructional Rounds were based around a problem of practice that district leadership co-developed with principals. Karen, the director of Instructional Rounds in Cypress described Instructional Rounds as being about, "the learning of the participants, them calibrating what they're seeing, how they describe it and when they're talking about words like rigor, engagement, what does that actually look like and feel like in a classroom? It's more about looking at students".

Like Almond Valley, Cypress was trying to move away from pull-out professional learning for teachers. However, Cypress still had two such opportunities during the 2018-19 school year: teacher leader training and new teacher professional learning. Teacher leaders were selected from across the district (at least one per grade level) to serve as mathematics leaders. Teachers were selected because they were known as strong mathematics teachers and had a willingness to learn more. As part of their teacher leader responsibilities, teachers

attended trainings facilitated by district math coaches three times per school year. During the year of this study the content of the three trainings were (1) leveraging student responses, (2) connecting conceptual understanding to procedural fluency, and (3) mathematics intervention strategies. Teacher leaders were also expected to post their mathematics lessons and their reflections to Google Classroom at least once per month; all teachers in Cypress had access to Google Classroom and could see and comment on posts. Finally, the expectation was that teacher were open to being videoed or opening their classroom to visits from other teachers in the district who wanted to see an example of high-quality mathematics instruction.

New teacher professional learning sessions were voluntary, full-day trainings for first year teachers or teachers who were new to the district. They were facilitated by district math coaches and occurred three times per semester (the same professional development three different times to allow for smaller groups of teachers to experience the learning). In general, these professional learning sessions were intended to deepen teachers' understanding of the Core Curriculum as well as the CCSS-M. To do this, facilitators usually started by engaging teachers in a Math Talk which is one of the district's Signature Strategies. Then they would do a math task from the curriculum and the facilitators would model another one of the Signature Strategies such as Groupwork Feedback or Three-Read Protocol. To familiarize teachers with the CCSS-M, the facilitators would then have teachers work on an activity where teachers traced the standards in one domain from kindergarten to fifth grade. In the afternoon, teachers were given time to plan with colleagues, with the idea being that coaches were present to provide support.

Induction coaching was another structure for participation in Cypress. There were two induction programs in the district. For new teachers to clear their teaching credentials (i.e., satisfy all requirements for their teaching degree) they had to spend two years in one of the two programs. Each model had its own specifics for what coaching looked like, but generally they required that teachers engaged in several one-on-one coaching cycles per school year. A coaching cycle consisted of a pre-observation meeting where the coach and teacher co-plan a lesson together and decide on the focus of the observation, the observation, and the post-observation meeting where the coach and teacher reflect and discuss next steps.

Lesson Study and school-based coach support were both school-level participation structures that the district level sometimes latched onto when mathematics content support was needed. Lesson Study is a Japanese model of teacher-led research in which teachers work together to target an identified area for development in their students' learning (Saito, 2012). Using existing evidence, participants collaboratively research, plan, teach, and observe a series of lessons, using ongoing discussion, reflection, and expert input to track and refine their instructional interventions. Lesson Study was not necessarily math-specific in Cypress, but there were a fairly large number of schools engaged in math Lesson Study because of a math-specific grant. The focus of school-based coach's support and what they actually did in schools was determined through individual negotiation between the school-based coach and their principal.

Finally, Cypress coaches provided ongoing coaching in Cypress to a small number of low-resource, high-needs schools across the district. Like school-based coach support, the focus of coaching depended on individual negotiation between the district math coach and the school

leaders at their assigned schools. Coaches tended to work with school leaders (principals, APs, school-based coaches) to find out what the school's plans were related to mathematics instruction and to determine how they could integrate themselves in those plans to best serve teachers and work towards overall instructional improvement goals. Faith, the math manager, described the different forms coaching could take here:

> There is some leadership coaching, which could look like supporting the teacher leaders, possibly to develop an agenda, possibly in the classroom. There are a lotta ways that that could look. There could also be coaching of teams, because ultimately the vision is moving towards a site-based PLC, so working with a team of teachers together would be another version of coaching.

Chapter Summary. I found that both districts designed infrastructures for elementary mathematics to guide, support, and improve elementary mathematics instruction. These included formal roles, resources, and participation structures (see Table 7). For the most part, both districts designed similar component parts. These included role groups such as assistant superintendents, math coaches, and school leaders of various sorts that shared similar responsibilities. Both districts adopted or developed a mathematics curriculum and had accompanying documents to support its use. Both districts had interim assessments. Both districts designed various pull-out teacher professional learning sessions (e.g., regional teacher PL in Almond Valley and tew teacher PL in Cypress) and coaching of various sorts as well as supports for school leaders.

Three key differences also stand out. First, Almond Valley had an instructional framework in mathematics (the IPG) while Cypress did not. Second, Almond Valley had a classroom walkthrough structure that members from all levels of the district participated in

while Cypress did not. Third, Cypress had school-based participation structures (i.e., Lesson Study and school-based coach support) that the district may or may not have been involved with while all structures in Almond Valley included district leaders of various sorts.

Table 7. Core elements of infrastructure for elementary mathematics by district

	Almond Valley	**Cypress**
Roles	• Assistant superintendents • Math coaches (and math manager) • School leaders	• Assistant superintendents • Math coaches (and math manager) • School leaders
Resources	• IPG • *Go Math* • Quarterly Planner • Interim/KinderAssess assessments • 6-to-8 Week Plan	• Core Curriculum • Math Teaching Toolkit • Milestone assessments
Participation Structures	• Classroom walkthroughs • IPWs • District ILT meetings • Coaching • Regional teacher PL	• Cohort meetings • New teacher PL • Teacher leader training • Coaching • Induction coaching • Lesson Study • School-based coach support

Chapter 6
Characterizing the Designed Infrastructures

Both districts adopted student learning goals that were aligned with the CCSS-M and promoted a vision of teachers' instruction that was broadly compatible with NCTM's Principles to Actions. Both districts also designed infrastructures to support these goals. While the two infrastructures looked somewhat similar in terms of their component parts described in the previous chapter (i.e., both had instructional materials, participation structures for teachers and school leaders to learn, and role groups at the district and school levels that shepherded mathematics teaching and learning), a closer look at some key dimensions of Almond Valley and Cypress's infrastructure designs show they made different strategic choices.

In this chapter, I show how these two district infrastructures for elementary mathematics varied along four dimensions: inclusivity, authority, specificity, and alignment. More specifically, I argue that the designed infrastructure in Almond Valley had high inclusivity, authority, and specificity (see Table 8). Regarding alignment in Almond Valley, designs for school leader and teacher learning were well-aligned with the instructional framework, and, while the content of the instructional materials and assessments was well-aligned with the standards, the cognitive demand of the mathematical tasks was not. In Cypress, the designed infrastructure had low inclusivity and authority, and medium specificity. Teacher learning was moderately aligned with the instructional framework, but school leader learning was not aligned. For the most part, the content and cognitive demand of the instructional materials and assessments were well-aligned with the standards. The rest of this chapter is divided into four sections (one for each dimension) where I share evidence for my designations in Table 8.

Table 8. Designations for each dimension of the district infrastructure for elementary mathematics

Dimension	**Almond Valley**	**Cypress**
Inclusivity	High	Low
Authority	High	Low
Specificity	High	Medium
Alignment		
Instructional Materials	Content: High Cognitive Demand: Low	Content: High Cognitive Demand: Medium
Assessments	Content: High Cognitive Demand: Low	Content: High Cognitive Demand: High
School Leader	High	Low
Teacher Learning	High	Medium

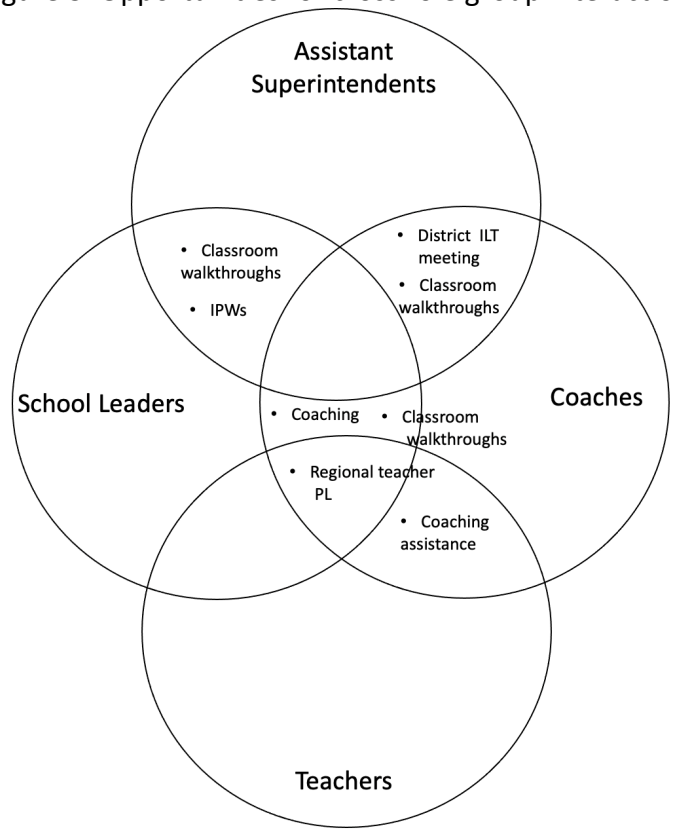
Inclusivity

Inclusivity is the degree to which the infrastructure provides routinized opportunities for interaction between different role groups on issues of mathematics. Inclusivity is an important part of infrastructure (especially in larger school districts) because professionals need regular time and space to learn with and from one another. This learning time allows district leaders to standardize their instructional program, set and maintain direction, and monitor progress, among other things. I found that Almond Valley had high inclusivity and Cypress had low inclusivity. More specifically, in Cypress there were no opportunities for interaction between mathematics coaches and assistant superintendents and limited opportunities for interaction between math coaches and school leaders. Almond Valley, on the other hand had designed participation structures that connected these role groups.

As I described in Chapter 5, the same role groups were responsible for elementary mathematics instruction in both districts: assistant superintendents, coaches, and school leaders. However, the ways in which each district designed participation structures within

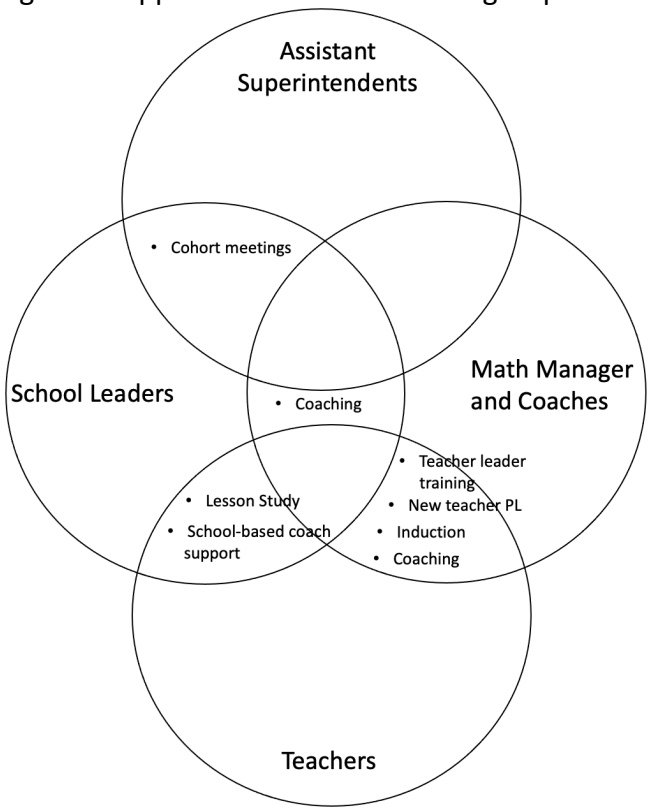
which these role groups could interact about mathematics was different. In Almond Valley, elementary mathematics coaches had at least one designed opportunity for interaction with three different role groups—teachers, school leaders, and assistant superintendents (see Figure 3 below). More specifically, coaches had two designed opportunities for interaction with assistant superintendents (classroom walkthroughs and district ILT meetings), two designed opportunities with school leaders (classroom walkthroughs and coaching), and two designed opportunities with teachers (coaching and regional teacher PL). Importantly, regional teacher professional learning often brought together three role groups at once—coaches, teachers, and school leaders. Indeed, coaches often included school leaders as either co-facilitators or active participants in their professional learning sessions with teachers.

Figure 3. Opportunities for cross role group interaction about mathematics in Almond Valley



In Cypress, on the other hand, coaches had at least one designed opportunity for interaction with only two role groups—school leaders and teachers (see Figure 4 below). Designed opportunities with school leaders were limited because coaching was only offered to a small subset of low-resource elementary schools across the district (approx. 15 schools). Thus, coaches in Cypress did not have access to school leaders in most elementary schools across the district in any routinized way. Coaches had several designed opportunities for interaction with teachers, including teacher leader trainings, new teacher PL, induction coaching (for teachers still clearing their teaching credentials), and ongoing coaching (for teachers in coaches' focus schools). Importantly, math coaches had no designed opportunities for interaction with assistant superintendents. The dearth of opportunities for interaction between district math coaches and assistant superintendents in Cypress is not uncommon in school districts. Indeed, the siloed work of district leadership departments and curriculum and instruction departments is a well-documented problem (Hightower et al., 2002).

Figure 4. Opportunities for cross role group interaction about mathematics in Cypress



Authority

Authority is the degree to which the infrastructure is designed to monitor or hold school leaders and teachers accountable to the district's student learning goals and instructional vision in mathematics. Authority is an important part of infrastructure to consider because an accumulation of research suggests that strong accountability or monitoring mechanisms are likely to encourage a degree of school and classroom change. At the same time, this change may be superficial, or school leaders and teachers may resist oversight, suggesting that a balance must be struck. I found that Almond Valley's infrastructure had high authority and Cypress's had low authority. In Almond Valley, data were collected at both the student and teacher levels to monitor learning and instructional practices. School leaders and teachers

engaged earnestly with this data and treated it as fairly high stakes. The math curriculum was mandated across the district and administration monitored its use. Coaches often cycled back to observe teachers' instruction after coaching. In Cypress, student data were collected but it was not used in routine or regular ways across the district; some assistant superintendents reviewed data regularly with school leaders, others did not. Some school leaders reviewed data regularly with teachers, others did not. No instructional data were collected. Further, Cypress's math curriculum was encouraged not mandated; the district ultimately left this decision up to the school site.

Authority in Almond Valley

Student achievement on interim assessments in Almond Valley served as a way for the district to monitor student learning. As described in Chapter 5, three times per school year, students in first grade and above were administered an interim mathematics assessment (kindergarten took a separate assessment); the results from these assessments were then supposed to be reviewed by leaders at multiple levels of the system to inform improvement efforts. When asked if teachers' pay attention to their students' achievement on the interim assessments, Tallulah told me, "I feel like a lot is tied to them. I feel like teachers are very aware of them." This quote indicates that Tallulah's impression from teachers is that they felt the authority behind the district's interim assessments. School leaders were also very tuned into student scores on the interim assessments. One school leader illustrated this when she said, "One of the reasons why I focused on math this school year is 'cause we dropped in math on

the interim. We have never dropped in math before. I have never dropped in math at any school I've ever been at, so it was disheartening for me."

Teachers' instruction was also monitored to ensure it aligned with the IPG. The IPG was supposed to be used by teachers in their planning and by school and district leaders when observing instruction. Data from these observations were entered into a system-wide database that all district and school level administrators had access to. Thus, not only did Almond Valley have a system-wide resource that clearly laid out the district's vision for a high-quality mathematics classroom, but that resource was used in such a way that teachers were monitored for those types of practices in their classroom. Although district leaders said that the IPG was not an evaluation tool, teachers often saw it that way. In one interaction, I observed Tallulah and an elementary principal planning for an upcoming teacher professional development that they would then co-facilitate at the school. They were trying to figure out how to draw in the IPG as part of that learning. At one point in that interaction the principal said, "My goal here for teachers would be for teachers to see that the IPG is not to be separate from lesson planning and often we don't see it out during planning. I've modeled it [during planning], but it's foreign to them because they see it as an evaluation tool" (Fieldnotes, 02/27/19). Again, this field notes excerpt shows that school leaders perceived that teachers felt the IPG was backed by authority.

Almond Valley also monitored the use of their adopted curriculum, *Go Math*. *Go Math* was district-mandated, that is, all K-12 teachers were expected to be using the curriculum during their core math instructional time. During the 2018-19 school year, assistant

superintendents monitored the use of the curriculum by pulling student workbooks to see if they were completed, paying particular attention to whether the higher cognitive demand tasks were done. School leaders took this curriculum mandate seriously. When asked about his expectations for how teachers use the curriculum, one school leader said, "So, teachers need...during the core math time, that should be the only curriculum they use, whether it's teaching from that or using some of its resources like the *Math on the Spot* videos."

The way coaching was designed also held teachers accountable to teaching in ways that were aligned with the district's mathematics vision. When appropriate, coaches engaged teachers in what they called "a cycle of support." A cycle of support required that coaches circled back to teachers after working with them in some capacity (either a professional learning session, PLC, or one-on-one work) to observe instruction for shifts that the teachers learned about. Coaches were often joined by the principal during these observations. In this way, teachers were held accountable to trying to implement what they were working on with coaches.

Authority in Cypress

In Cypress, student achievement data (i.e., Milestone assessments) were scored by teachers and collected twice per year by the district, but the degree to which this data was used varied by school. When asked how these data were used, Olaf said:

> We are interested in how teachers use that data to improve instruction, and that's where we try to focus. I've heard everything from it's used for that to it's used by principals or other administrators to compare schools or compare kids or to ride teachers or whatever. People use it for what they use it for. Right?

Unlike Almond Valley, these data did not factor into how coaches worked with school leaders or teachers. Math coaches told me they "hoped" that teachers used these data to inform instruction, but there were no mechanisms in place to support teachers or schools in doing this. Regarding teachers' use of Milestone data in their instruction, Olaf said, "Like everything else in Cypress, it's so variable [laughs]. You know? Different schools do it different ways. Different teachers do it different ways."

Cypress also didn't monitor instruction. Although Cypress did not have an instructional framework like Almond Valley's IPG, it was clear that they were aiming to get teachers across the district to implement the three Signature Strategies: Math Talks, Three-Read Protocol, and Groupwork Feedback. But, when asked how they get an idea of what math instruction looked like across the district (including whether teachers were implementing these strategies), district math coaches said it was "informal" and "anecdotal."

The primary resource in Cypress that outlined expectations about mathematics instruction was the Core Curriculum and accompanying Math Teaching Toolkit. However, use of the curriculum in Cypress and implementation of teaching strategies from the Math Teaching Toolkit was not mandated or monitored by the district. Indeed, many schools and teachers across the district used other curricular materials, the most popular of which was Japan Math. Supplemental programs and resources were also not regulated, so schools tended to choose what they wanted when a need arose. For example, one of Olaf's focus schools, Paul Robeson Elementary, purchased Marilyn Burns's *Do The Math* program with school funds for students that needed intervention in mathematics. Because this program was purchased with school

funds there was no district oversight regarding the quality of the program of how it complimented (or did not compliment) the Core Curriculum.

Finally, unlike Almond Valley, none of Cypress's work with teachers had any follow-up or mechanisms for holding teachers accountable to implementing what they learned.

Specificity

Specificity is the degree to which the infrastructure provides clear and detailed guidance about what to teach and how to teach it. It is an important dimension of infrastructure to consider because, on the one hand, teachers need some level of guidance regarding what to teach and how, especially since the inception of statewide learning standards. On the other hand, too much specificity may be burdensome or may not allow teachers the flexibility that is needed with different groups of students.

I found that Almond Valley had a highly specified infrastructure and Cypress's infrastructure had medium specificity. As you can see in Table 9 below, both districts specified what math content to teach by providing a curriculum and clearly stating the student learning goals of the lesson (i.e., the understandings or skill students should leave the lesson with). For example, in the 2nd grade lesson I analyzed about addition within 100, the Core Curriculum in Cypress had a section at the beginning of the lesson titled "Core Math" and where it specified that students would learn the following, "When adding two-digit numbers, we can add the tens to the tens and the ones to the ones." In the comparable lesson in Almond Valley, *Go Math* also specified the learning objective, although with different language: "Apply place-value concepts

when using a break-apart strategy for 2-digit addition." Almond Valley also provided a more thorough description of the student learning goals of lessons in their Quarterly Planner.

Table 9. Specifications in each district and where it was specified

		Almond Valley		**Cypress**	
		Specified?	If yes, where?	Specified?	If yes, where?
What to teach	Content	Yes	*Go Math*	Yes	Core Curriculum
	Goal(s) of lesson	Yes	*Go Math* and Quarterly Planner	Yes	Core Curriculum
	Route to reach learning goals of the lesson	Yes	*Go Math*	No	Na
How to teach	Pacing and sequencing	Yes	Quarterly Planner	Yes	Core Curriculum
	Timing of different parts of a lesson	No	Na	No	Na
	Models/representations/tools to use or have available for students to self-select	Yes	*Go Math* and Quarterly Planner	Yes	Core Curriculum
	Core instructional practices	Yes	IPG	No	Na

Regarding how to teach, both districts specified the sequence of math topics as well as pacing either in the body of the curriculum (Cypress) or in the Quarterly Planner (Almond Valley). Neither district specified the timing of different parts of each lesson and both districts specified the models, representations, or tools that teachers should use in their instruction or have available for students to self-select.

There were two differences in the specificity of the infrastructure in Almond Valley and Cypress: the route to reach the learning goals of the lesson and core instructional practices (see highlighted rows in Table 9). Almond Valley specified both and Cypress specified neither. The

two curricula were very different regarding the route to reach the learning goals of the lesson. Lessons in Cypress's Core Curriculum provided a small set of more open-ended math tasks for teachers and students to engage in. Utilizing a Launch-Explore-Summarize format, students were expected to problem-solve how to solve tasks in collaboration with their peers and with scaffolding by the teacher (without the teacher taking over the task and showing them how to do it). In the Summarize portion of the lesson the teacher uses students' problem-solving strategies to facilitate a discussion that compares strategies and discusses connections between mathematical representations. In *Go Math*, on the other hand, the mathematical tasks were broken down into a series of manageable steps that—if executed properly—would lead students to the learning goals of the lesson.

Finally, and perhaps most critically, Cypress did not specify the core instructional practices that align instruction with the district's vision of a high-quality mathematics classroom. In other words, there was no shared reification that individuals in the district could turn to that specified how teachers should be teaching and what should be happening between teachers and students to ensure that students reach the learning goals. In Almond Valley, on the other hand, the IPG served this purpose.

Alignment

Alignment is the degree to which there are coherent connections between different components of the infrastructure and the student learning goals or instructional framework. It is an important part of infrastructure because an accumulation of research suggests that policy

alignment is associated with teachers' instruction that is aligned with shifts called for in the policy as well as student achievement in both mathematics and ELA.

Alignment was component dependent. That is, some components were well-aligned with the standards or instructional framework while others were less so. Overall, I found that Almond Valley took an especially systemic approach to their learning systems, threading their instructional framework through the district's approaches to school leader and teacher learning. In spite of district efforts to create linkages between the CCSS-M and their curricula and assessments via the Quarterly Planner, I found low alignment in cognitive demand between the curricula and assessments on the one hand, and the standards on the other. Thus, within a systemwide approach in Almond Valley, there were disjunctures in the resources used to guide teaching and learning. By contrast, Cypress had few system-wide approaches to instructional improvement. It did not have a fully fleshed out instructional framework akin to the IPG in Almond Valley, its approaches to school leader learning were emergent, and its teacher learning system was expansive such that some opportunities were well-aligned and others were not. However, the district-created curricula and assessments had high alignment with the CCSS-M. Thus, there was medium to strong alignment between the resources and supports that reached teachers in the absence of an overall systemwide approach in Cypress (see Table 10 below for all alignment designations).

Table 10: Summary of alignment in Almond Valley and Cypress's infrastructure for elementary mathematics

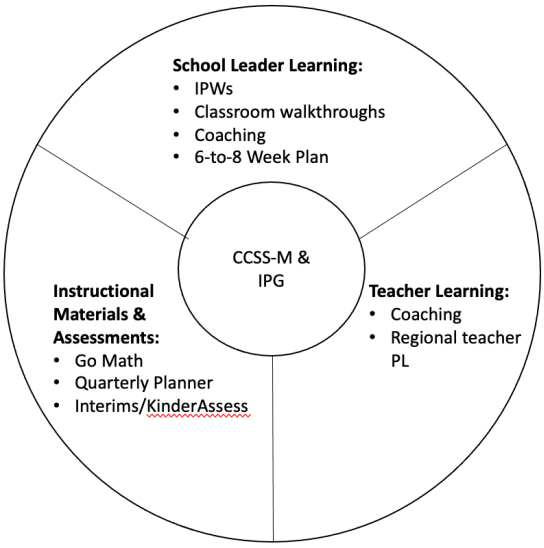
	Almond Valley	Cypress
Instructional Framework	---	---
Instructional Materials	Content: High Cog. Demand: Low	Content: High Cog. Demand: Medium
Assessments	Content: High Cog. Demand: Low	Content: High Cog. Demand: High
School Leader	High	Low
Teacher Learning	High	Medium

Note: The instructional framework in both districts served as the anchor by which other components were compared which is why it doesn't have a high, medium, low alignment designation (i.e., the framework can't be compared against itself).

Alignment in Almond Valley

In Almond Valley, the CCSS-M served as their student learning goals and their instructional framework was the IPG. These composed the centerpiece of their infrastructure for elementary mathematics (see Figure 5 below).

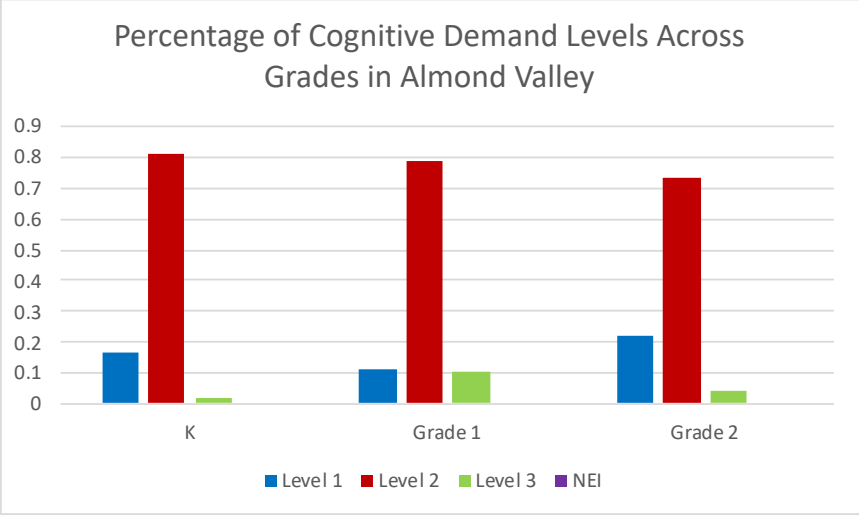
Figure 5. Almond Valley's Infrastructure for Elementary Mathematics



Instructional Materials and Assessments. In Almond Valley, teachers used *Go Math* as their curriculum. Regarding content, I found that *Go Math* was well aligned with the CCSS-M

because *Go Math* was comprehensive (all of the standards were covered). While there was high alignment in content, we found low alignment in cognitive demand. The CCSS-M are designed so students have the opportunity to engage in tasks that have a range of cognitive demand in each grade level. This implies that an ideal curriculum would have tasks within each grade that were an equal mix of cognitive demand levels. We did not find this to be the case in Almond Valley. Across kindergarten, 1st, and 2nd grades there was not a balance in cognitive demand levels (see Figure 6 below); indeed, there were few activities with level 3 cognitive demand (strategic thinking) and none with level 4 (extended). Moreover, 73 percent of the activities in grades K-2 were level 2 cognitive demand. Thus, *Go Math* was not providing students the opportunity to engage in the kinds of mathematical thinking and problem solving that are required in the CCSS-M and we deemed it had low alignment in cognitive demand.

Figure 6. Percentage of cognitive demand levels across grades in Almond Valley



It is important to note that the mathematics department in Almond Valley did recognize this weakness in their curriculum and developed the Quarterly Planner as a band aid of sorts.

Laverne described the Quarterly Planner's purpose when she said, "So the curriculum is our guaranteed and viable curriculum, meaning that's what we're gonna use for our instruction. But, if we know that our curriculum is lacking in some areas, we'll put some additional resources or templates or tools in the Quarterly Planner."

For the most part, the content in the district assessments (KinderAssess for kindergarten and interims for 1st and 2nd) was well aligned with the *Go Math* curriculum (see Table 11 below). KinderAssess focused on seven of the nine most salient (i.e., content that appeared in more than 25 activities) topics in the curriculum (78% overlap), 1st grade interims focused on six out of the 11 most-salient topics from the curriculum (54% overlap), and 2nd grade interims covered 6 out of the 7 most-salient topics from the curriculum (86% overlap). On the other hand, the cognitive demand of tasks in the district assessments was not well aligned with the *Go Math* curriculum. Overall, there was lower cognitive demand in the assessments than there was in the curriculum. Across all interim assessments for K-2, items were only coded at cognitive demand levels of 1 and 2. Even within these levels, the percentage of different levels were not similar to the levels represented in the curriculum. For example, 43 percent of the items in the KinderAssess were level 1 compared to 17 percent in the kindergarten curriculum units, 24 percent of the items on the 1st grade interims were level 1 compared to 11 percent in the 1st grade curriculum units, and 30 percent of the items on the 2nd grade interims were level 1 compared to 30 percent in the 2nd grade curriculum units.

Table 11. Alignment in content and cognitive demand between assessments and the curriculum in Almond Valley

	Content	Cognitive Demand
Kindergarten	High	Low
1st Grade	Medium	Low
2nd Grade	High	Med

School Leader Learning. I found high alignment between school leader learning and the instructional framework (IPG) in Almond Valley. During the 2018-19 school year, the district invested heavily in learning for school leaders in mathematics, mostly through math-focused IPWs and classroom walkthroughs that were grounded in the IPG. According to one assistant superintendent, "We've done a lot of professional learning with principals, and in fact, all professional learning this year has revolved around the two tenets of our IPG, challenging content and academic discourse." Indeed, I was able to confirm this focus in an observation of an IPW where an assistant superintendent facilitated learning for principals focused on the importance of lessons that intentionally target the aspects of rigor (conceptual understanding, procedural skill and fluency, application) called for by the standards. Specifically, they focused on how principals can support their teachers in thinking about when and how they are providing instructional scaffolds to their students, ensuring that teachers don't over-scaffold such that they are "losing the rigor." Below is a field note excerpt where the assistant superintendent is discussing instructional scaffolds with the principals:

> This takes you guys [principals] taking an inventory of your school for the amount of scaffolding happening and the need for the amount. It is different depending on the students you're getting. If you're getting a new set of students who are more prepared, you can't assume you'll use the same methods and maintain improvement…The first part is knowing how much of this is happening among your teachers. Knowing how to work with teachers to reduce as needed. Knowing how many exceeding kids are in your class and getting rid of having them do

> "Unlock the Problem" with the scaffolds. That's an easy move! We need to take those easy moves. We will hit a ceiling if we don't do this…We're hitting ceilings [in student achievement] already because these scaffolds for all are the same.

Every IPW ended with principals walking classrooms with the IPG to specifically observe for what they had just done some learning around. For example, after the learning around instructional scaffolding, school leaders walked classrooms with the IPG as their observation rubric, paying particular attention to indicators of instructional rigor. Outside one of the classrooms the principals debriefed:

> School leader takes out an IPG form. The group agrees that on Tenet 2A, there appeared to be focus, coherence, and rigor in that the content was appropriate. For 2B, they said there was not as much rigor because they [students] were re-doing work they had already completed. They also noted that many of the students were just playing with the manipulatives, perhaps because they already had the answer to the question before the manipulatives were presented. They agreed to say that the classroom "somewhat" met 2A and 2B on the IPG.

All classroom walkthroughs—not just those done as part of IPWs—utilized the IPG as an observation rubric. Further, because support school leaders received from district math coaches was based on what they observed during classroom walkthroughs, it follows that coaching was aligned with the IPG.

Finally, the 6-to-8 Week Plan was utilized by assistant superintendents to keep school leaders' learning and improvement efforts aligned with the high-leverage instructional practices called for in the IPG. Just as coaching was based on what school leaders, assistant superintendents, and coaches observed during classroom walkthroughs with the IPG, so too was the problem of practice identified in the 6-to-8 Week Plan. In this way, the 6-to-8 Week Plan served as a tool to help the district create better alignment in the system by focusing

principals' school improvement actions on indicators of high-quality mathematics instruction found in the IPG. As one assistant superintendent explained to a group of principals during an IPW:

> There is so much that comes through your door. We [principals] have the squirrel effect, going from one thing to another. That's the life of a principal and I know it because I was in it for many years. I believe the 6-to-8 Week Plan is one thing that has helped us to say, let's focus on one thing that's archived…so I can chunk my learning and the actions that are happening.

Overall, because of the consistent focus on instructional approaches linked to the IPG in mathematics, I judged that learning provided to school leaders had high alignment with the instructional framework in Almond Valley.

Teacher Learning. I also found high alignment between teacher learning and the IPG in Almond Valley. There were two primary learning structures for teachers in Almond Valley during the 2018-19 school year: regional teacher PL, and coaching. The progression of learning in the regional teacher PLs followed the progression of content in *Go Math,* and math coaches supported teachers in deepening their content knowledge through engaging in rigorous math tasks and using tools. They also worked with teachers to anticipate student solutions, representations, and common errors. Rigorous math tasks, tools, and student solutions and representations were all called out in the IPG as shown in the bullets below:

- "The lesson intentionally targets the aspect(s) of **rigor (conceptual understanding, procedural skill and fluency, application)** called for by the standard(s) being addressed."

- "Students use **appropriate tools**, including technology, strategically when solving a problem."
- "The teacher strengthens all students' understanding of the content by **sharing a variety of students' representations and/or solution methods.** "

These regional teacher PL sessions were also specifically designed to focus on the two tenets of the IPG that the district was especially focused on during the 2018-19 school year: instructional rigor and academic discourse. Regarding this even narrower focus Tallulah explained, "We don't want to do a million different things in a million different areas." For example, included in the learning goals for one regional teacher PL was, "Learn how to support students with productive struggle and discourse through open strategy sharing and questioning." Another was, "Learn how to structure and lead productive mathematical discussions that include explanations with reasoning." Again, these learning goals were explicitly called out in the IPG as shown in the bullets below:

- "Students have **opportunities for productive struggle** and demonstrate perseverance in reasoning and solving problems in the face of initial difficulty" (IPG: Mathematics)
- "Students engage in **academic discourse** and ask questions about each other's thinking to clarify, self-assess, and/or improve their own mathematical understanding and determine next steps to improve learning outcomes" (IPG: Mathematics)

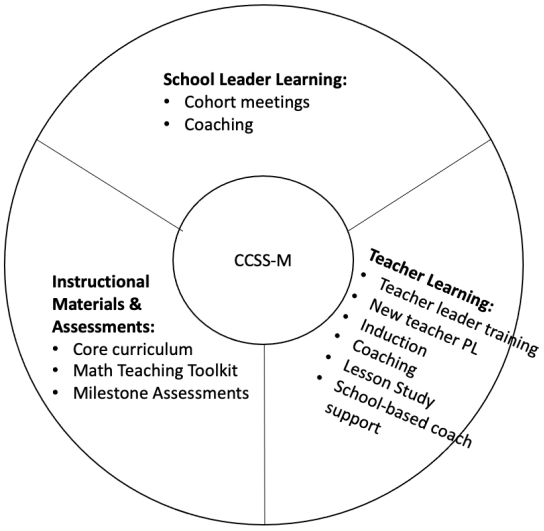
Like coaching support to school leaders, the focus of coaching for teachers was typically determined through ongoing conversations with school staff while walking classrooms with the

IPG. Therefore, it was what they observed in classrooms as compared against the IPG that determined the focus of support.

Alignment in Cypress

Cypress did not have an instructional framework like Almond Valley. Instead, the CCSS-M composed the centerpiece of their infrastructure, serving as both the student learning goals and instructional framework (see Figure 7 below).

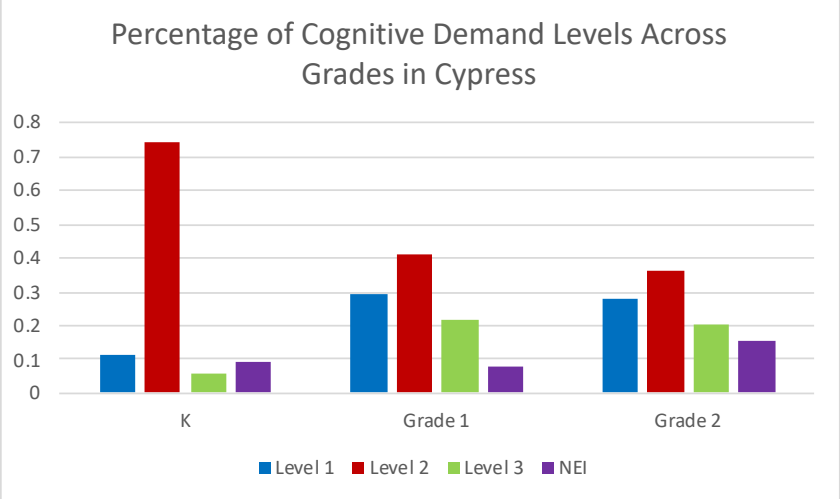
Figure 7. Cypress's Infrastructure for Elementary Mathematics



Instructional Materials and Assessments. The district encouraged schools to use the Core Curriculum, but as discussed in the authority section, curricular decisions were ultimately left to schools. For the purposes of this study, however, I analyzed the degree to which the Core Curriculum was aligned with the CCSS-M. Regarding content, we found that the curriculum was well-aligned with the CCSS-M. That is, all the number and operations standards (because we only analyzed number and operations units) were sufficiently covered in the curriculum. Regarding cognitive demand we found that the curriculum was moderately aligned with the

standards because, while the majority of the analyzed grade levels had more of a balance between cognitive demand levels (the exception being kindergarten), the curriculum did not include any activities that were assigned a cognitive demand level 4 by our coders (see Figure 8 below).

Figure 8. Percentage of cognitive demand levels across grades in Cypress



For the most part, content in the milestone assessments was well aligned with the Core Curriculum (see Table 12 below). The kindergarten milestones focused on four of the six most salient (i.e., content that appeared in more than 25 activities) topics in the Core Curriculum (67% overlap), 1st grade milestones focused on five of the 6 most salient topics from the curriculum (83% overlap), and 2nd grade milestones covered 7 out of the 8 most-salient topics from the curriculum (88% overlap). The majority of the analyzed grade levels also had high alignment in cognitive demand between their milestone assessments and the curriculum. For example, 33 percent of the items on the 1st milestone assessments were level 1 compared to 30 percent in the 1st grade curriculum units, and 33 percent of the items on the 2nd grade interims were level 1 compared to 28% in the 2nd grade curriculum units. Kindergarten was the

exception with 33 percent of the items in the kindergarten milestone were level 1 compared to just 11 percent in the kindergarten curriculum units.

Table 12. Alignment in content and cognitive demand between assessments and the curriculum in Cypress

	Content	**Cognitive Demand**
Kindergarten	Medium	Low
1st Grade	High	High
2nd Grade	High	High

School Leader Learning. I found low alignment between school leader learning and the instructional framework (in this case the CCSS-M) in Cypress. Unlike Almond Valley where both assistant superintendents engaged their principals in the same foci for instructional improvement aligned with the IPG, assistant superintendents in Cypress worked independently of one another. Further, their guidance was characterized by a lack of focus on mathematics.

The primary learning structure for school leaders were the monthly cohort meetings facilitated by assistant superintendents. The focus of these meetings was different depending on the cohort, but generally, across the district there was a lack of focus on mathematics. According to a director of one of the cohorts, “I would say our work, specifically with math, has been more limited than in past years. This year, we’ve been focusing more on literacy and language development.” Instructional rounds were a common structure utilized by assistant superintendents during monthly cohort meetings, however the coordinator of instructional rounds in Cypress explained that math was rarely the focus when she said, “It [math] does not come up that often. A lot of times, we’re going into all the classrooms. Usually in the elementary, the principals are focused on literacy.”

Another way that school leaders could learn about mathematics teaching and learning in Cypress was through coaching from district math coaches. As a reminder, coaching was only offered to a small number of high-need, low-resource elementary schools across the district. Like the focus of cohort meetings, however, the focus of coaching was different by coach and by school because it was determined through individual negotiation between the math coach and the school leader they were supporting.

Teacher Learning. I found medium alignment between teacher learning and the instructional framework in Cypress, that is, some structures for teacher learning were well-aligned with the standards and others were not. Both pull-out professional learning structures in Cypress, new teacher PL and teacher leader trainings, were well-aligned with the CCSS-M. New teacher PLs were primarily focused on deepening new teachers' understanding of the core math curriculum which, as I've described above, is generally well-aligned with the CCSS-M. During the 2018-19 school year teacher leader trainings focused on topics like how to leverage student responses and connecting conceptual understanding and procedural fluency. Both structures consistently and repeatedly emphasized the Signature Strategies promoted by the curriculum that were consistent with the mathematical practices in the CCSS-M. For example, at the start of all professional learning sessions, district math coaches engaged teachers in a Math Talk (one of the Signature Strategies). Math Talks served to further students' understanding of math content while also addressing Standard for Mathematical Practice #3: *Construct viable arguments and critique the reasoning of others*. New teacher PLs and teacher leader trainings were not available to all elementary teachers; new teacher PLs were only open

to first year teachers or teachers who were in their first year in the district and teacher leader trainings were only available to a select group of high-quality mathematics teachers.

Lesson study, when math-focused, was also well-aligned with the CCSS-M, although not every school had this learning structure nor were all the schools that had this learning structure utilizing it for mathematics. Although the focus of lesson study depended on the teaching team's research question (e.g., in one school their research question was, "How does our math instruction support the development of independent learners?"), the consistent focus on student thinking and learning suggests Lesson Study is likely to help teachers learn the shifts called for in the CCSS-M. For example, during the lesson study public research lesson, the observers don't focus on the teacher; they focus on the students. How are the students reacting to the lesson? What are they understanding or misunderstanding? The purpose is to improve the lesson based on student understandings, not to critique the teacher.

Determining whether induction coaching, school-based coach support, and coaching were aligned with the CCSS-M was difficult because the focus differed from school to school and coach to coach. There was, however, two characteristics about these structures that suggests they were not well-aligned. First, the focus of all three was typically determined through one-on-one negotiation between the induction coach, school-based coach, or district math coach and the school leader. Second, induction coaches and school-based coaches tended to not focus on mathematics instruction, either because their principal was focused on literacy or because they themselves didn't feel comfortable coaching in mathematics. According to Liza, "We get a lot of e-mails from new teachers that say can you come do a coaching cycle because

my induction coach says they can't do math, that it's not their expertise. We typically can't fulfill all those requests."

It is noteworthy that there were many ways in which teachers could receive professional learning in Cypress. First year teachers in Cypress's high-need, low-resource schools could technically get support in mathematics from all six structures if their school happened to be a Lesson Study school and if their school leaders were focused on mathematics. One can imagine that aligning all six sources of learning could be challenging especially when different role groups are responsible for different learning opportunities (e.g., district math coaches facilitate new teacher PL, school-based coaches provide support, induction coaches provide induction coaching). This state of affairs in Cypress is in contrast to Almond Valley that only had two structures for teacher learning in mathematics, both of which were facilitated (or at least co-designed) by district math coaches.

Chapter Summary. While the two infrastructures looked somewhat similar in terms of their component parts described in Chapter 5, Almond Valley and Cypress made different strategic choices when designing their infrastructures for elementary mathematics. I found that these strategic choices differed along four dimensions: inclusivity, authority specificity, and alignment. More specifically, I found that Almond Valley's infrastructure had **high inclusivity** and Cypress's infrastructure had **low inclusivity**. Both districts designed multiple participation structures for coaches to interact with teachers, but only Almond Valley's infrastructure connected coaches to assistant superintendents and school leaders. Cypress coaches did

support school leaders through coaching but only school leaders in their focus schools, thus they were not connected to most elementary schools.

Second, I found that Almond Valley's infrastructure had **high authority** while Cypress's infrastructure had **low authority**. In Almond Valley, student and teacher data were regularly collected to monitor student learning and teaching practice. *Go Math* was mandated, and its use was monitored by school leaders and assistant superintendents. Teachers were also held accountable for implementing practices that they learned about in professional learning. In Cypress, student data were collected but there were no expectations for their use. No instructional data were collected. The Core Curriculum was not mandated and there was no follow-up to teacher professional learning.

Third, my analysis revealed that Almond Valley's infrastructure had **high specificity** and Cypress's had **medium specificity**. Two key differences in specificity warranted these designations: 1) Almond Valley's curriculum specified a detailed route to reach the learning goals of the lesson while Cypress's did not and 2) The IPG in Almond Valley specified core instructional practices while Cypress did not have an equivalent specification.

Finally, alignment of each infrastructure's component parts differed. In Almond Valley, teacher and school leader learning were well-aligned with the district's instructional framework (**high alignment)** while in Cypress school leader learning was not aligned with their instructional framework and only some teacher learning structures were aligned (**low and medium alignment respectively**). Regarding instructional materials and assessments, the content of Almond Valley's instructional materials and assessments were well-aligned with the CCSS-M,

but the cognitive demand was not (**high and low alignment respectively**). In Cypress, both the content and cognitive demand of the materials and assessments were well-aligned (**high and medium/high respectively**).

Chapter 7
How Coaches Enacted Their Role

In Chapter 5 I described the *designed* infrastructures within which district math coaches worked in both Almond Valley and Cypress. This broad view of each infrastructure design highlighted the role groups assigned responsibility for elementary mathematics, the resources, materials, and tools available for these role groups to work with, and the participation structures they were able to engage in to enact their role. In Chapter 6 I took this descriptive analysis one step further to examine the dimensions (inclusivity, authority, specificity, and alignment) along which these infrastructures varied, dimensions that scholars suggest are potentially important for school and district practice. In this chapter, I zoom in on coaches in each district and their lived practice within these infrastructure designs. In particular, I examine the coaching tasks coaches engaged in to enact their role and the nature and content of the interactions that constituted those tasks.

Overall, I found that coaches in the two districts undertook five common coaching tasks: 1) observing and debriefing teachers' instruction, 2) planning and facilitating teacher professional learning, 3) responding to individual teacher needs, 4) planning for school improvement, and 5) building district level capacity (see Table 13 below for definitions of each coaching task). Cypress coaches enacted one additional task: outward-facing tasks. The enactment of these tasks differed between districts in five key ways: 1) the relative balance in time spent on different coaching tasks, 2) the degree to which coaches undertook these tasks by themselves or with different role groups, 3) the degree to which coaches leveraged common district mathematics resources, 4) the degree to which coaches' interactions with teachers focused on

how to use or coordinate instructional materials, 5) the degree to which coaches' interactions with other coaches focused on teaching and learning, and 6) the variability in the nature and content of coaches' practice within a given district.

Table 13. Coaching tasks and definitions

Coaching Task	**Definition**	**Almond Valley**	**Cypress**
Observing and debriefing teachers' instruction	The observation of either a full mathematics lesson or a portion of a lesson as well as a debrief with the teacher and/or others afterwards.	✓	✓
Planning and facilitating teacher professional learning	The work required to plan for teacher professional learning sessions as well as the actual facilitation of learning for small and large groups of teachers.	✓	✓
Responding to individual teacher needs	Meeting one-on-one with a teacher because of a more urgent and/or individualized need.	✓	✓
Planning for school improvement	The work required to determine where district math support was needed and what that support should look like.	✓	✓
Building district level capacity	The work at the district level that was intended to improve the district's collective capacity to fulfill its mission of supporting schools instructionally.	✓	✓
Outward-facing tasks	Interfacing with actors from outside the district for various purposes.		✓

In this chapter I provide evidence for these claims through two case studies of coaching practice: one of coaching in Almond Valley and one of coaching in Cypress. In each case study, I first introduce the coaching tasks coaches engaged in to enact their role and the relative amount of time they spent on each task. Much of the literature on coaching has treated coaching practice as amorphous, leading to difficulties measuring both coaching practice itself and the potential outcomes of coaching. Therefore, I found it important to empirically identify

what coaches were actually doing in these two districts. I then examine the nature of the interactions that constituted those tasks, including who coaches interacted with, the designed resources they used during their interactions, how they used them, and the focus of their interactions. Coaching tasks get enacted in the fields of social interaction between and among coaches, teachers, and other district and school personnel. By digging deeper into the interactions that comprised the task I can be more precise in not only what coaches do but how they do it.

Coaching Practice in Almond Valley

Laverne and Tallulah engaged in five primary coaching tasks in the enactment of their coaching roles in Almond Valley (see Table 14 below): 1) observing and debriefing teachers' instruction, 2) planning and facilitating teacher professional learning, 3) responding to individual teacher needs, 4) planning for school improvement, and 5) building district level capacity.[8]

Table 14. Coaching tasks in Almond Valley

Coaching Task	Instances observed	Number of interactions that composed instances
Planning and facilitating teacher professional learning	12	36
Observing and debriefing teachers' instruction	7	45
Responding to individual teacher needs	3	16
Planning for school improvement	4	28
Building district level capacity	4	10
TOTAL	**30**	**135**

Note: As discussed in Chapter 4 (Methodological Approach), interactions are defined as talk between a coach and someone else that revolved around a singular focus. Several interactions could be nested within a single task.

[8] From interviews I also know that Almond Valley coaches co-planned lessons and analyzed student work with teachers, but I did not observe them enacting these tasks during my shadowing. Descriptions of these coaching tasks from interviews did not provide me with enough information for my analysis of interactions so these coaching tasks were not included in my findings.

Overall, I found striking similarity between the two coaches (Laverne and Tallulah) in what coaching tasks they enacted. Both coaches focused their efforts on planning and facilitating teacher professional learning and observing & debriefing teachers' instruction. Less time was spent responding to individual teachers' needs, planning for school improvement, and building district level capacity. Both coaches often co-enacted tasks with professionals in the district's administrative line (i.e., school leaders and assistant superintendents) and interacted around a myriad of common district math resources in almost all tasks, most prominently the IPG, *Go Math,* and the interim assessments. Laverne and Tallulah leveraged these resources to guide their observations, align their planning with school and district improvement goals, direct their supports, and anchor their professional learning with teachers, among others. While a proportion of coaches' interactions with teachers focused on instructional practices and student thinking and learning, they also focused on how to use or coordinate instructional materials and superficial features of classroom instruction. Coaches' interactions with other coaches overwhelmingly focused on the specifics of teaching and learning, including core instructional practices and student thinking and learning.

Planning and Facilitating Teacher Professional Learning

Planning and facilitating for teacher professional learning entailed the work required to plan for professional learning sessions as well as the actual facilitation of learning for small and large groups of teachers. This task constituted the most of Tallulah and Laverne's time. I observed 12 instances of this coaching task (nine instances of planning and three instances of

facilitating) between Tallulah and Laverne. These 12 instances constituted 44 percent of the total time I spent observing both coaches.[9]

Planning for Teacher Professional Learning

With whom? Planning teacher professional learning was often co-enacted with other coaches and school leaders. All eight observed instances of planning were co-enacted with either other coaches (n=6) or a school leader (n=2). I observed several instances of coaches sitting together in their office sharing and offering feedback on their designs for teacher professional learning. I also observed two instances of coaches supporting school leaders in the design of teacher professional learning sessions that the school leader would then facilitate or that the coach and school leader would co-facilitate; interviews with coaches confirmed that this was one primary way that coaches provided support to school leaders.

Resources. Both coaches used the district's math curriculum (*Go Math*), the 6-to-8 Week Plan, and the IPG during planning. Most teacher professional learning sessions were anchored in *Go Math* so both Tallulah and Laverne used the curriculum while planning (e.g., tasks were selected from the curriculum for teachers to work on). I observed the curriculum being used in some form or fashion in all planning. For planning that was co-enacted with school leaders, I also saw Laverne and Tallulah use the 6-to-8 Week Plan to align their planning with the schools' current instructional improvement goals. For example, in one planning session between Laverne and a school leader, Laverne used the school's current 6-to-8 Week Plan to frame the

[9] This amount of time may have been inflated because during one of my shadowing windows Tallulah and Laverne were both preparing for a half-day teacher professional learning session with an entire region of elementary teachers.

professional learning session they were planning. The session was going to be focused on the progression of student learning from kindergarten to 2nd grade:

> Your 6-to-8 week goal is for 2nd grade to be heavily fluent in solving 2-step word problems with addition and subtraction, so what is the backwards mapping? What is solving a 2-step word problem with addition and subtraction and what is all the underlying sensemaking and learning a kid has to do to get there? In some ways we are framing your goal. If we want all kids to be able to do this kind of math in 2nd grade, we gotta make sure kindergarten is doing certain things and 1st is doing certain things.

Finally, coaches also used the IPG during planning to focus their learning designs around the district's two major areas for improvement called out in the IPG for the 2018-19 school year: rigor and academic discourse. As Laverne described, "Because one of our foci this year is on academic discourse, we try to infuse or model questioning and strategies that you can use as a teacher in our professional learnings…like asking teachers to like give choral responses or partner A and B and then thumbs up/thumbs down or tell your partner and explain why."

Focus. 65 percent of interactions between coaches and other coaches or coaches and school leaders were focused on designs for teacher learning including a discussion of why or the purpose behind the learning design (see Appendix C for the full breakdown of foci). I found that this was regardless of whether coaches were interacting with one another or with a school leader. For example, in the following field notes excerpt, Tallulah is supporting a principal in planning a teacher professional learning session that focused on the selection and enactment of mathematical tasks:

> **Tallulah [reading from the shared google doc in front of them]:** Effective teaching in mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving, allows multiple entry points, and varied solution strategies [end of reading from the google doc]. Not every single

> task in the curriculum will have all these great things that a task should have so teachers need to learn some teacher moves…obviously teachers don't have time to plan every single lesson, every single day with their grade-level PLC, but there are a couple lessons that PLCs should do together to understand the grand focus like distributed property in third grade.
> **Principal:** I've never seen a PLC working it out [*She has never seen a PLC doing math together].*
> **Tallulah:** It's important [teachers working out tasks together]. We can select a great task, but as a teacher I need to work through it and plan for different student responses.
> **Principal:** Is that the a-ha! from this professional learning? That if you are just following the curriculum and filling out stuff in the book you are going to be at a 2 in the IPG, not a 3?
> **Tallulah:** Yes.

This example shows that through interaction with Tallulah, the principal is gaining a deeper understanding of why they are designing teacher learning about mathematical task selection. That is, a high-quality lesson that builds on student thinking and reasoning requires more than page-turning a textbook but rather requires that teachers prepare by working out tasks, anticipating student strategies, and thinking about how they might advance student thinking based on those strategies.

Facilitating Teacher Professional Learning

With whom? Like planning for teacher professional learning, coaches in Almond Valley often co-enacted the actual facilitation of teacher professional learning with other coaches and, at times, school leaders. Of the three enactments of this coaching task that I observed, two were enacted alone and one was enacted with other math coaches. However, I know from interviews with coaches that school leaders sometimes co-enacted with them. Who coaches facilitated teacher professional learning with typically depended on the setting in which it occurred. Facilitation occurred in one of three settings in Almond Valley: whole-region, whole-

school, or grade-level PLCs. For whole-region learning, coaches split up by grade level and facilitated by themselves. Whole-school professional learning sessions were typically co-enacted by several coaches. For both whole-region and whole-school opportunities, school leaders were often in attendance and, at times, facilitated some of the less math-content-specific pieces of the session. According to coaches, the inclusion of school leaders was intentional because school leaders served as an indicator to teachers that they would be held accountable for implementing the learning. In addition to facilitating pieces of the session, school leaders often engaged in the learning with their teachers. For smaller groups of teachers such as grade-level PLCs coaches tended to enact the session by themselves.

Resources. In the facilitation of all professional learning opportunities that I observed or heard about, the coaches used the *Go Math* curriculum and the Quarterly Planner. For example, regional teacher professional learning sessions closely followed where the teachers were at in the *Go Math* curriculum. During these trainings, I observed coaches engage teachers in math tasks from the curriculum and facilitate learning around the key standards for each lesson. Coaches used the Quarterly Planner as a reference for teachers to help them ensure their use of the curriculum met the standards. Other types of professional learning (i.e., whole-school or grade-level PLC support that district math coaches engaged in as part of their ongoing coaching assistance) were also anchored in the *Go Math* curriculum.

Focus. The big-picture focus of teacher professional learning was determined through student data and ongoing classroom observations (with the IPG) as well as conversations

between coaches, school leaders, and assistant superintendents. Triston, the elementary math manager, described the process here:

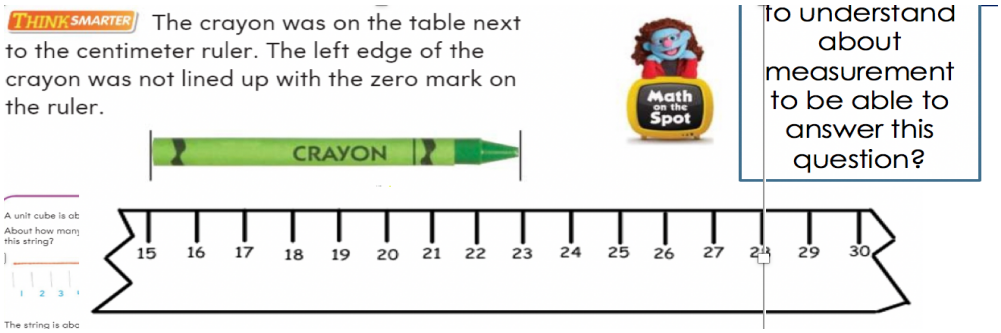
> …we always have had a structure where as we look at data, as we walk all classrooms with the IPG, as we visit all schools, we engage in discussions with leaders and staff about the mathematical needs there. That, oftentimes, results in next steps. One of the things that we do as we walk classrooms is we think through, what are the next steps? Next step suggestions sometimes have to do with teacher learning. That, sometimes, will then lead to some sort of teacher professional learning opportunity. The origins of it [learning opportunities] aren't necessarily the site just requested. It's that we, as a team, have noticed some needs through classroom observations or data. We're always looking at top-performing schools, lower-performing schools, top-growing schools, and schools that didn't grow on any of our data pieces—on observational pieces, as well as interim scores, as well as SBAC. That, we try to do, and then we try to get to all of it [*laughs*].

Through this process, Almond Valley coaches were able to be intentional about the learning goals of the professional learning they engaged in with teachers. According to Triston, observations of teachers' practice with the IPG, student achievement data (both interim and SBAC), and ongoing conversations with others involved in supporting elementary mathematics across the district all combined to make this possible.

38 percent of all interactions between coaches and teachers during professional learning opportunities were about doing mathematical tasks together with discussion. Tallulah indicated that as a coaching team they were diligent to ensure that engaging teachers in doing mathematical tasks together was a common practice in all their professional learnings. Indeed, during all three instances I observed of coaches enacting this task, the coaches engaged teachers in solving mathematical tasks just as a student would. Then coaches had teachers circle back to reflect on what they just experienced as a learner (e.g., what might make the task

difficult for students) as well as the instructional moves that the coaches made (e.g., how did the coach support without over-scaffolding or how did the coach check for understanding).

15 percent of the interactions were about student thinking and learning. For example, in one regional teacher professional learning, Tallulah engaged teachers in the following task from *Go Math*:



On white boards, Tallulah asked teachers to write what a correct student explanation would sound like on one side and what an incorrect explanation would sound like on the other. After eliciting potential correct and incorrect student explanations, Tallulah asked the teachers to talk in small groups about what different student solution strategies reveal about what students need to understand about measurement to answer the question. In this way, Tallulah is directing teachers' attention to student thinking and their understandings instead of it "being about the problem."

Despite these deeper, more substantive interactions (i.e., doing mathematical tasks together with discussion and student thinking and learning), I also found that 23 percent of the interactions between coaches and teachers during the facilitation of teacher professional learning were about how to use or coordinate the instructional materials. As Laverne described to a 3rd grade teacher she was supporting, "Most of our math trainings are 'how to use,' 'how

to do,' format of a 5E lesson [structure around which the curriculum is built – Engage, Explore, Explain, Elaborate, and Evaluate]." A key theme in these "how to use or coordinate the curriculum" interactions was supporting teachers in learning how to adapt the curriculum to better align with the standards. For example, on several occasions, coaches told teachers to project singular questions from the curriculum on their document cameras and then prompt students to work on them in notebooks (as opposed to their *Go Math* workbooks). The reason given for this strategy was that the curriculum tended to over-scaffold student learning. Thus, for students to work on tasks with the rigor called for in the CCSS-M, teachers needed to be strategic about the tasks presented to students instead of just "filling in lines in a workbook."

Observing and Debriefing Teachers' Instruction

The coaching task of observing and debriefing teachers' instruction (*henceforth referred to as ODTI for readability purposes*) entailed a coach being in a teachers' classroom during mathematics instruction to observe either a full lesson or a portion of a lesson and debriefing with the teacher and/or others afterwards. During my time shadowing Laverne and Tallulah, I observed seven instances of ODTI (or 23 percent of the total observation time).

With whom? When coaches in Almond Valley enacted ODTI, they typically did not do so on their own (i.e., with just the teacher); instead, they co-enacted ODTI with another coach or coaches, school leaders, or assistant superintendents. Of the seven times I observed Laverne or Tallulah enact ODTI, two were co-enacted with other math coaches, three were co-enacted with a school leader, and two were co-enacted with both another coach and a school leader. While I did not observe coaches co-enacting ODTI with assistant superintendents, interviews

with coaches, the math manager, and assistant superintendents revealed that they did indeed enact ODTI together on a regular basis.

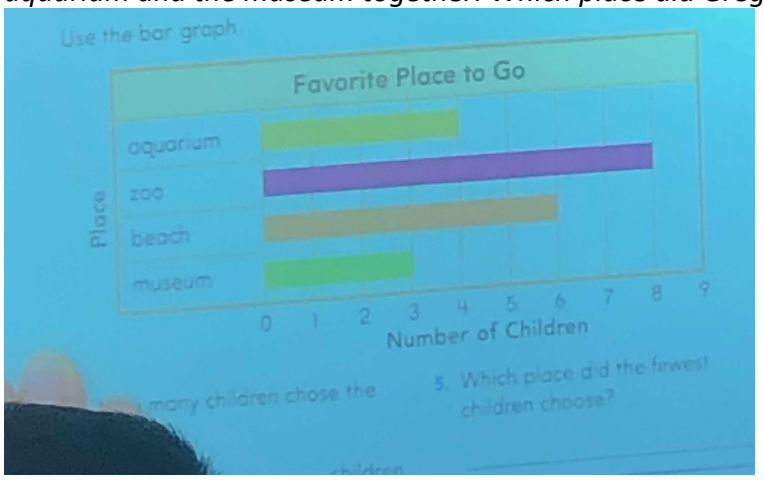
Resources. During enactment of ODTI, Almond Valley math coaches used the IPG and interim assessments. Coaches and others always used the IPG to guide their observations and subsequent interactions. As Laverne explained, "I always carry around the IPG with me when I'm observing classrooms because it lists the indicators of what you might see in a classroom for each tenet. I show it to principals on walks." During ODTI I often saw coaches and others carrying paper copies of the IPG; I also saw electronic versions of the IPG on cell phones.

Interim assessments, another district resource, also played a role in ODTI in that interim data often determined where Laverne and Tallulah enacted ODTI. Before one instance of ODTI, I asked Laverne for some background on the purpose. Laverne told me that the school came up at one of their math team meetings where Triston said there is something "really bad going on in math at [school] based on their interim data." Laverne told me that the other coach she was enacting ODTI with was the one to reach out to the principal because of a previous relationship. The other coach then told me, "I've already looked at the school's interim data and tried to picture what the problem might be, whether that is new teachers, veteran teachers, lack of focus, or no backward planning from the standards." Thus, it appeared that interim data, in addition to directing coaches to particular schools, was also used to triangulate or add further context to the instructional practices that coaches observed in classrooms.

Focus. The majority of the interactions during ODTI focused on instructional strategies (31 percent) and student thinking and learning (20 percent). The instructional strategies

discussed were aligned with the high-leverage instructional practices called for in the IPG such as the rigor of the math task, teachers' use of mathematical representations, and teachers' use of student representation or solution strategies as a way to strengthen all students' understanding of the content. When interactions were not focused on the high-leverage practices in the IPG, the IPG was used by coaches to refocus interactions. During one such instance, Tallulah and a school leader were co-enacting ODTI in a 2nd grade teachers' math classroom. In the classroom students were working on the following math task:

Math Task from *Go Math* curriculum: *Greg chose a place that has more votes than the aquarium and the museum together. Which place did Greg choose?*



The correct answer was the zoo. When we left the classroom the school leader mentioned to Tallulah that as he looked over students' shoulders at their work, they all seemed to have the correct answer. He was happy about this. Tallulah agreed with him about students getting the right answer; however, Tallulah went on to say that she circulated the classroom while students worked in small groups and asked students about their reasoning for their answer. Tallulah said that many students either said that the answer is the zoo "because it's the longest [referring to the fact it was the longest bar on the graph]" or simply stated "4 plus 3 equals seven."

According to Tallulah, these responses indicated that students could not reason about the core mathematical idea of the task which was about comparing the sum of four and three with the other bars on the graph. Tallulah goes on to tell the school leader that if the teacher simply looked for the correct answer without pushing students for their thinking and reasoning (an indicator on the IPG), the teacher would have no way of knowing that students were not getting at the core mathematical idea (and indeed this was Tallulah's feedback to the teacher). In this interaction with a school leader, Tallulah used the IPG to redirect the focus of the interaction from being about getting the correct answer, to being about the importance of teachers pushing for students' mathematical reasoning (a key tenet in the IPG), including *why* this teaching practice was so important.

20 percent of the interactions were about student thinking and learning. Again, these interactions tended to be anchored in the student practices outlined in the IPG. These included practices such as whether students had the opportunity for productive struggle, how student engaged in academic discourse, and whether and how students used appropriate mathematical tools when problem-solving.

While 51 percent of coaches' interactions during ODTI were focused on either instructional practices or student thinking and learning called for in the IPG, there were also interactions that did not. These interactions included talk about superficial features of classroom instruction (20 percent) such as how the student desks were arranged, how the teacher organized different parts of the lesson, or student behavior. A common theme among these interactions was that they tended to happen when the IPG was used as a checklist. For

example, I observed talk that was about whether the teacher was using the curriculum or not or whether students were using mathematical tools or not, without a discussion of *how* tools were being used or *why*. I also observed interactions about how to use or coordinate instructional materials (13 percent) such as interactions about where teachers are at in the scope and sequence.

Responding to Individual Teacher Needs

The coaching task of responding to individual teacher needs (*henceforth referred to as RTN for readability purposes*) entailed a coach meeting with a teacher because of a more urgent or individualized need. These meetings were one-off occasions and not connected to other work the coaches or the teachers were engaged in. I observed three instances of this coaching task (approximately 13 percent of the total observation time).

With whom? Almond Valley coaches enacted RTN alone. For the most part, Almond Valley coaches did not respond to (or tried to not respond to) these types of requests. Triston, the elementary math manager, explained why when he said:

> If a teacher says, 'I want a coach to come help me plan,' we look for a higher grain size just because I don't have the capacity right now. We invite her to invite her grade level. [Laughter] Call them and we say, 'Can we do a grade level PLC?' Not just the one teacher. When a principal says, 'Hey. I have this one teacher that's really, really struggling,' we tell the principal, 'Can we work with their grade level PLC?' The school or the PLC level 'cause we also don't wanna just put out fires with individual teachers. We wanna be seen as a support for the whole team struggling and non. All teachers can get better. Sometimes it's also the support for the PLC team in helping them get better so they can learn from each other.

Resources. During the three enactments of RTN that I observed, Laverne and Tallulah used the *Go Math* curriculum or the IPG. During one instance where the IPG was used, Laverne

"whisper coached" a teacher who was being evaluated by her principal the following day. Whisper coaching was a form of in-the-moment coaching in Almond Valley where the coach pulled the teacher aside while students were working or talking to provide feedback about the lesson. Laverne used the IPG to observe and provide feedback. When I inquired with Laverne whether she frequently worked with teachers before principal evaluations she said that all the coaches get a lot of requests from teachers before they get evaluated. In another instance of RTN, Laverne used *Go Math* during interactions with a 3rd grade teacher who was having trouble structuring her core instructional time in mathematics so that she could successfully differentiate instruction. Laverne used *Go Math* to show the teacher how she could use different parts of the curriculum in ways that would help with differentiation.

Focus. 31 percent of the interactions during RTN were about instructional strategies. Like the interactions during ODTI, the instructional strategies discussed were aligned with the high-leverage instructional practices called for in the IPG. For example, during Laverne's whisper coaching, Laverne provided feedback related to instructional practices called for in the IPG including, suggestions for academic discourse moves she could use to get students talking to each other about the math, pointing out a student error that the teacher could highlight and talk about with the whole class, suggesting that the teacher make a connection between mathematical representations, and suggesting that the teacher instructs with more urgency and moves from one activity to the next more quickly once it's clear that students have "got it." At the same time, coaches also engaged in interactions with teachers that focused on how to use or coordinate instructional materials and superficial features of classroom instruction (31

percent and 19 percent, respectively). Indeed, in all three instances I observed of RTN in Almond Valley I saw coaches talk to teachers about how to structure each part of the 5E lesson (the lesson structure in *Go Math).*

Planning for School Improvement

Planning for school improvement (*henceforth referred to as PSI for readability purposes*) was a task Laverne and Tallulah engaged in that entailed the work required to determine where district math coach support was needed and what that support should look like. I observed three instances of Laverne and Tallulah enacting PSI (approximately 12 percent of the total time). Almond Valley coaches enacted PSI because they did not have the capacity to support all elementary schools in the district. As a reminder, during the 2018-19 school year there were only six district math coaches. Thus, they had to make strategic decisions about where they would provide math support and what that support would look like.

With whom? PSI was co-enacted by the elementary math coaching team (including the elementary math manager) and was primarily enacted at the weekly team meeting. A majority of coaches' time during Friday team meetings was spent on this type of coaching task (I also observed this time being used for planning teacher professional learning and building district level capacity).

Resources. Coaches used the IPG and interim assessments during their enactment of PSI. IPG data from classroom observations served as the centerpiece around which coaches interacted to discuss current instructional practice and how it could be improved. In particular, discussions among coaches were anchored in the coaches' IPG reports that they completed

after observing instruction in classrooms. Reports included information about the grade levels that were observed, IPG scores for each classroom and evidence for those scores, a narrative about the problem of practice based on the scores, and next steps. Often reports also included information that coaches learned from interactions with school staff during their visit such as the collegiality of different grade level teams or the mathematical representations in the curriculum that teachers struggled with. For each team meeting, coaches brought print outs of their reports and presented them to the team before opening it up for team discussion regarding what the evidence suggested for the type of support teachers may need.

Interim assessment data also played a role in PSI enactment. After each interim assessment, the math manager, brought a printout of interim scores by school and grade level to share with the coaches. In one meeting I observed after the second interim assessment, I saw coaches intently reviewing scores for their grade level (coaches are grade-level specific in Almond Valley) and highlighting schools where the scores from the second interim in 2017-18 to the second interim in 2018-19 dropped. The plan was that they would reach out to those school leaders to try and schedule a time to observe instruction and "figure out what was going on." In this way, the district's interim assessments focused coaches' attention on schools with low student achievement data.

Focus. 47 percent of the interactions during PSI focused on instructional practices or student thinking and learning (29 and 18 percent, respectively). Below is an excerpt of an interaction about instructional practices that exemplified interactions during PSI in Almond Valley. I observed this interaction at one of the weekly elementary math team meetings.

Coaches were discussing some recent classroom observations that they did at one school as a follow-up to a recent whole-school professional learning session:

> **Other district math coach:** 3rd grade was encouraging. Initially when we did the first observation [they had previously observed the Explore portion of the lesson after the first professional learning that they did at this school] the kids were struggling with even tiling and it was difficult for them to make sense of the math. In that observation, teachers were trying the planting garden task I modeled. Teachers did not have questions to guide students so their idea of "Explore" was still self-discovery so part of my feedback was when you give a task you have to plan for what may be the student misconceptions. You can't just give them stuff and say "hey, go self-discover." This time it was much better. Kids were not just tiling they were doing two rectangular arrays of 24 square units and from tiling to drawing on the grid paper to compare area and perimeter. Most kids were engaged and understanding.
> **Triston:** That's reassuring because it means we are eliciting stuff. We will work with them further. It seems like what you are seeing is the need for learning that pinpoints the importance of productive teacher questioning and how to seek evidence of students' learning and that will be one of the drivers for learning next year. Laverne?
> **Laverne:** For 1st grade, it's still a lot of teacher direction. A lot of teacher talk, a lot of "pulling sticks" [*By "pulling sticks" she means selecting sticks with student names on them as a way to call on students. Laverne explains that the teachers felt like they had to "pull sticks" for this particular lesson because there weren't enough manipulatives for every child or even groups of children to use*]. But the rest of the students who weren't being called on were disengaged. Also, the outcome of the learning wasn't to put together blocks but to put together a new shape and name it. One of the teachers was struggling but she was at least attempting. We need to do better with outcome and objective and not being page turners. Students were literally circling shapes in the math workbooks.
> **Triston:** What are things in the system that are helpful to teachers in being able to determine the learning goal and the focus?
> **Laverne:** Our Quarterly Planner.
> **Other district math coach:** Honestly what I think it comes down to is teacher time and planning. Planning lessons instead of opening the book and doing it.
> **Tallulah:** Yeah, they are literally going to a lesson and picking up a problem and it becomes about this problem right here instead of math identity and math practices.

In this interaction, coaches use observations of teaching practice (collected with the IPG) to make judgements about current practice and how to further support teachers. It also points to an example of coaches using other resources in the system to help them convey information about mathematics instruction to teachers across the district (i.e., the Quarterly Planner helping teachers be able to determine the learning goal and focus of lessons.)

Building District Level Capacity

The coaching task of building district level capacity (*henceforth DLC for readability purposes)* entailed work at the district level intended to improve the district's collective capacity to fulfill its mission of supporting schools instructionally to align with the CCSS-M. Almond Valley coaches did not spend much time enacting DLC (eight percent of the total time observed).

With whom? Coaches co-enact the task with other district math coaches.

Resources. I did not observe coaches using any of the common district math resources during their enactment of DLC.

Focus. The focus of interaction differed depending on the district level project coaches were working on. During my time shadowing Laverne and Tallulah this task included two primary projects (although Laverne and Tallulah said that the projects shifted over the course of the school year as different district needs or initiatives arose): the development of the summer school mathematics curriculum and CORE work. CORE work was related to Almond Valley's participation in California's CORE district initiative. In this initiative, eight districts across the state were working together to test improvement theories and foster meaningful collaboration

and learning across district sites. Two elementary schools in Almond Valley were engaged in this work focused on student math achievement for African American and Latinx students; in particular, they were working on an improvement science cycle on the use of mathematical tools and representations. Some of the math coaches were engaged in that work with them because of their math content expertise.

Coaching Practice in Cypress

Liza and Olaf engaged in six primary coaching tasks to enact their coaching roles: 1) observing and debriefing teachers' instruction, 2) planning and facilitating teacher professional learning, 3) responding to individual teacher needs, 4) planning for school improvement, 5) building district level capacity, and 6) outward-facing tasks (see Table 15).[10]

Table 15. Coaching tasks in Cypress

Coaching Task	Instances observed	Number of interactions that composed all instances
Planning and facilitating teacher professional learning	8	26
Observing and debriefing teachers' instruction	6	30
Responding to individual teacher needs	2	11
Planning for school improvement	4	12
Building district level capacity	5	45
Outward-facing tasks	6	12
TOTAL	**31**	**136**

Overall, in Cypress, I found that coaches focused their efforts on building district level capacity, planning and facilitating teacher professional learning, and outward-facing tasks. Less time was spent observing and debriefing teachers' instruction, planning for school improvement, and responding to individual teacher needs. Only two tasks (planning for school improvement and planning and facilitating teacher professional learning) were, at times, enacted with school leaders; indeed, many of the tasks were enacted by themselves or with other district math coaches. The Core Curriculum was used as foundational material for some

[10] From interviews I also know that Cypress coaches co-planned lessons with teachers and analyzed student work with teachers, but I did not observe them enacting these tasks during my shadowing. Descriptions of these coaching tasks from interviews did not provide me with enough information for my analysis of interactions so these coaching tasks were not included in my findings.

of the coaches' professional learning sessions. It was also used during interactions with teachers while responding to individual teacher needs and during some of the outward-facing tasks, but other than this, Olaf and Liza rarely used or interacted around the common district resources. Digging deeper, I found that, for the most part, coaches' interactions with teachers tended to be about student thinking and learning, instructional practices, and doing math together with discussion. Indeed, their interactions tended to steer clear of more low-depth topics such as how to use or coordinate instructional materials and superficial features of classroom instruction. On the other hand, interaction amongst coaches tended to be about logistics and coordination of their work as opposed to substantive issues around teaching and learning. Finally, I found that once in schools, Olaf and Liza did different things from one another because they individually negotiated with each school leader and/or teacher regarding what their support would look like. Thus, the focus often shifted depending on teacher needs or choice, school leaders' directives, or coaches' own personal preferences.

Planning and Facilitating Teacher Professional Learning

I observed eight instances of this coaching task in Cypress between Liza and Olaf (two instances of planning and six instances of facilitating) which accounted for 24 percent of the total time I spent observing both coaches.

Planning for Teacher Professional Learning

With whom? Planning for teacher professional learning was co-enacted with other coaches and sometimes school leaders in the coaches' focus schools. In the two instances of planning observed, Liza interacted with other district math coaches to put together an agenda

for an upcoming teacher leader training. I did not observe Olaf planning for teacher professional learning however I know from interviews that in supporting one of his focus schools he is helping them "launch" whole-school Lesson Study.

Resources. In these instances of planning, Liza did not use any common district math resources. When Olaf supported his focus school in their implementation of Lesson Study, they used official Lesson Study materials and resources to help them understand the intricacies of the program.

Focus. 67 percent of the interactions that constituted the coaching task of planning for teacher professional learning in Cypress focused on the design of teacher learning activities, including a discussion of why or the purpose behind the learning design.[11] In one example that exemplified these interactions, Liza is talking to other coaches while planning for a teacher leader training. They are discussing a math game they want to play with teachers at the start of the session. At one point in the discussion Liza asks, "What do we want teachers to get from doing this game together?" This question then spurred interaction between coaches about the "why" or the purpose behind the decisions they were making as they designed the teacher learning experience. This question, or questions of a similar ilk, were common in both instances of planning that I observed.

[11] I only observed three interactions across two instances of planning for teacher professional learning so the sample size here is very small and thus it was hard to make inferences.

Facilitating Teacher Professional Learning

With whom? With whom coaches enacted this task differed depending on the setting in which the professional learning occurred. The facilitation of teacher professional learning typically occurred in one of three settings in Cypress: centralized professional learning, whole-school (only focus schools), or grade-level PLCs.[12] For centralized learning, coaches co-enacted with other coaches. For whole-school and grade-level professional learning coaches enacted sessions by themselves (because these were in their individual focus schools). Only teachers attended centralized, whole-school, or grade-level learning opportunities, that is, I never observed or heard about school leaders co-facilitating or even participating in the learning with their teachers.

Resources. Both Liza and Olaf used the Core Curriculum in some of their teacher professional learning sessions, but not others. For example, the Core Curriculum served as foundational material for the new teacher PLs.

Focus. The overall focus of central professional learning sessions (i.e., new teacher PLs and teacher leader trainings) was determined based on new teacher needs and coach choice. The new teacher PLs focused squarely on the curriculum because first year teachers or teachers that were new to the district needed an introduction to the Core Curriculum. Foci for teacher leader trainings, another centralized professional learning structure, were determined through coach choice. Because teacher leader trainings were for high-quality mathematics teachers that

[12] I only observed centralized and whole-school professional learning, so my analysis here only includes those settings.

wanted to get even better and serve as teacher leaders across the district, coaches typically chose to focus on deeper practices that would take their instruction to the next level (e.g., how to leverage student responses in instruction and conceptual versus procedural understandings). These trainings (i.e., teacher leader trainings) were not anchored to the Core Curriculum. Indeed, I did not see the Core Curriculum referred to or used during these trainings.

Besides the centralized teacher learning sessions (i.e., new teacher PLs and teacher leader trainings), the overall focus of teacher professional learning differed by coach and school because it was typically determined through one-on-one negotiation between school leaders and district math coaches. For example, I observed Liza facilitate teacher professional learning in two schools (one was a focus school, and one was not). At her focus school, Davis Elementary, Liza was finally able to get some teacher learning sessions scheduled about half-way through the school year. Liza and the school leader decided to work with the teachers on a "standards trace" from kindergarten to the fifth grade in one session and depth of knowledge (DOK) levels in another. When I asked Liza how they came up with these topics she said, "I just gave her [the school-based coach] some options and she picked what she wanted her teachers to work on." In another school (not one of Liza's focus schools), the school leader wanted his teachers to get support in looking at student work from a recent Milestone assessment, noticing strengths and weaknesses, and planning a re-engagement lesson based on that.

I observed Olaf facilitate teacher professional learning in one of his focus schools (two times). All of Olaf's support to this school (Paul Robeson Elementary) was done through the Lesson Study structure. Olaf had been working with Paul Robeson for several years when they

decided to pursue Lesson Study and invited Olaf to support them. According to the director of mathematics, it doesn't always work that a content-specialist (i.e., math coach) from the district level worked with schools engaged in Lesson Study as she described here:

> In the best possible version, there's somebody who has the structural understanding of Lesson Study. I mean it's a very heavy lift for a school. Then there's somebody who has the content expertise to support the deep inquiry around the standards. Then usually somebody from the math team does the final commentary, which is a very formal role in lesson study. The situations where it doesn't work as well are when the math team is an afterthought or something. It's really hard to come in later if the lesson's already been designed or to serve in a final commentary role if you don't have a relationship with the school. There are less successful examples also. It's a very tricky relationship.

This suggests that even when schools were engaged in math-focused lesson study, they may not work with someone who had math content expertise. This was not the case with Olaf and Paul Robeson. As part of his role, Olaf co-facilitated a grade-band team of teachers as they worked through a lesson study cycle (study—plan—teach—reflect). Olaf also provided the final commentary for public research lessons, which as the math director described is a formalized role in lesson study.

The overall focus of lesson study or what is referred to in Lesson Study as the "research theme" was determined through discussions at the school level about the qualities they wanted their students to have when they left the school. For example, Paul Robeson Elementary's research theme was about how their mathematics instruction can support the development of independent learners. Other schools across Cypress had different research themes such as how students can create a positive academic self-identify or how students can use evidence and reasoning to support and critique arguments.

29 percent of the interactions across both Liza and Olaf that constituted the coaching task of facilitating teacher professional learning were about doing mathematical tasks together. Doing math together was a pervasive practice at all teacher learning sessions as Liza described here:

> In any of our PD's that we do or any of our work when we're working in grade level teams, we always start with doing math together. Like, it could be as simple as a math talk or let's play a little game together or you know whatever. Something like that; like just doing math together. That is something we promote because it helps build community, it helps build like one's content knowledge, it helps somebody understand the standards a lot more.
> Equal in prevalence were interactions about student thinking and learning (29 percent).

For example, in one of Olaf's "final commentaries" as part of his support to Paul Robeson Elementary during Lesson Study, he debriefed the lesson plan, observation, and group sensemaking they all just finished engaging in during the public research lesson. At one point he directed the teachers' attention to a particular observation of student thinking he saw while observing the public lesson with the rest of the teachers. In this observation, two students were trying to sort shapes by different properties such as parallel and perpendicular lines, angle measures, and lines of symmetry:

> I found myself watching these girls, almost the whole time and they weren't talking a lot, so I didn't have a good view into their minds, right, but I kept wondering…they were putting those shapes in place for a reason, and I kept just wondering, why are they putting those there! It just reminded me that, it goes back to what Maria said last time, they know something. They have a conception. I don't know what it is, but they have a conception. So these two girls had sorted the shapes here on the left [points to a picture he had taken of their work] in what appeared to have something to do with the number of sides at first and when [teacher] came over and kind of clarified that then they took everything off and they went back to, you can see on the picture on the right [points to another picture he had taken of their work], they went back to parallel lines because they had a good idea about parallel lines and they still had the

> Venn diagrams with two circles, but they were kind of working with the one circle so that's kind of what they were showing me. That's where they were at…these have parallel lines, I know that. That's where I'm at.

In presenting this observation of student thinking to the teachers, Olaf signaled the importance of what students were doing in the classroom as opposed to the teacher. It also sparked an ensuing interaction about what the teachers now knew about the students' understandings, in this case that the student seemed to understand parallel lines but were having difficulties with other properties.

Observing and Debriefing Teachers' Instruction

ODTI was not a high-frequency coaching task in Cypress. I observed six instances of this coaching task in Cypress (three with Liza and three with Olaf) which accounted for 13 percent of the total time I observed.

With whom? All instances of ODTI were enacted alone (i.e., not with other coaches, school leaders, or assistant superintendents). All instances of ODTI occurred with Liza and Olaf's induction teachers. Cypress coaches, for the most part, did not observe instruction in teachers' classrooms across the district apart from the teachers they were supporting through induction. As described in Chapter 5, new teachers in Cypress participated in one of two induction programs. During the 2018-19 school year both Liza and Olaf had two induction teachers; Liza supported new teachers in one of the induction programs and Olaf supported new teachers in the other.

Resources. During their enactment of ODTI, Liza and Olaf did not use any common district math resources. Instead, they used resources developed by their respective induction

programs. For the most part, these resources were not math specific (i.e., they could be used for math or literacy).

Focus. The big-picture focus of ODTI was determined through a mix of teacher choice, principal directives, and the coaches' own personal judgments. Indeed, the focus differed between coaches and between teachers within a single coach. One of Liza's induction teachers had a principal that was very involved and more-or-less directed what Liza and the teacher worked on together. For the 2018-19 school year it was classroom management and the structures and routines that the teacher had (or didn't) to support it. Two of the three instances I observed of Liza were with this teacher, and indeed, the majority (53 percent) of the interactions that constituted those enactments of ODTI were about superficial features of classroom instruction such as incentives for student behavior, seating arrangements, and lesson transitions. The principal of Liza's other induction teacher was less involved, however Liza let this teacher take a lead role in determining the focus of their interactions. As Liza said during a lesson debrief:

> My style, [teacher name] just so you know, I let you do a lot of the heavy-lifting so I probably won't give you…you are probably going to mention a lot of the stuff I would mention to you anyway, um, but just so you know I'm not going to say, you need to work on this, you need to work on this. I want you to just kind of reflect.

In all three instances that I observed of Liza enacting ODTI, Liza also steered talk towards a topic of her own coaching persuasion: classroom equity. As Liza said, "One thing that I will focus on regardless of the teacher is equitable participation. To do this, I watch who the teacher tends to call on. I find that with many teachers it tends to be the black boys or the ELLs or newcomers that no one calls on or checks in with."

I also observed Olaf enacting ODTI with one of his induction teachers on three separate occasions. The majority of the interactions that constituted these enactments were about general discussions of how the lesson went and general discussion of students (57 percent). The field notes excerpt below of an interaction between Olaf and his induction teacher exemplified these foci:

> **Olaf:** One other little note I have because I know you are worried about [student]. He was fine after lunch. He was wacky in the morning, but better after lunch. He wasn't like that a month ago.
> **Teacher:** It's also like I'm trying to give time reminders so he can feel like he knows when things are wrapping up. He says he doesn't have time but then sits there for 4 of the 6 minutes they have to work saying he doesn't have time.
> **Olaf:** Is time pressure a problem with him?
> **Mindy:** Yeah.
> **Olaf:** I wonder if you could talk to him about that at the parent-teacher conference or maybe going to him a minute before you tell the rest of the class so he doesn't get flustered with time.

While I only observed Liza and Olaf enact ODTI that was anchored in mathematics instruction, I know from interviews that in their role as induction coaches, both coaches had to support induction teachers in all content areas. As Olaf explained, "We're supposed to mentor the teachers on whatever they need. So, unless, you know like some of my secondary colleagues they have a math teacher so math is all they do, but if we're supporting an elementary teacher I'm supposed to support them in whatever they're doing. I can try to point them toward math but that doesn't always work." Liza also said, "I've been lucky to do math coaching. I can tell you Olaf has done literacy coaching cycles." Thus, despite being district math coaches with a specialty in mathematics content and instruction, Liza and Olaf sometimes found themselves

having to coach in other content areas if that is what the teacher (or the teacher's principal) wanted to focus on.

Responding to Individual Teacher Needs

Cypress coaches tried to not respond to these types of requests from teachers because, according to them, they didn't have the capacity. Indeed, I only witnessed two instances of RTN (one with each coach that comprised four percent of the total time I spent observing). As Liza explained, "My role isn't to coach all the teachers on my case load. It's the school-based coach's role to coach. My role is to work with those school-based coaches and the admin to plan professional development."

With whom? Liza and Olaf enacted this task by themselves (i.e., just the coach and teacher).

Resources. Liza used the Core Curriculum while she explained the different parts of the lesson to the teacher. Olaf did not use a common district math resource in his enactment of RTN.

Focus. Liza enacted RTN when she responded to a kindergarten teacher who disliked the Core Curriculum and wanted to try another curriculum with her students (*Japan Math*). When I inquired with Liza as to whether responding to teacher issues or complaints about the Core Curriculum was common, she emphatically confirmed this. As Liza explained,

> You hear it [issues with Core Curriculum] for different reasons. You know, a school that has more English language learners will say it doesn't work for us because we have lots of English language learners who can't solve story problems. A school like [school] or [school] would say it doesn't work for us because it assumes that kids went to preschool or had this previous knowledge.

The three interactions that composed this coaching task were all focused on how to use or coordinate the instructional materials and logistics of teacher learning. For example, Liza explained to the teacher what each part of a lesson (Launch, Explore, Summarize) from the Core Curriculum was supposed to look like and how to get more support with using the curriculum from the math department. In our debrief interview, Liza told me that she was trying to get the teacher to see that "this curriculum or that curriculum" is not the silver bullet and that what she needed was time and structures at her school to explore the standards and the units with her grade level colleagues.

Olaf enacted RTN when he responded to a K-5 special education teacher that wanted support around math data in K-2. This teacher's role at the school was to work with students with formal IEPs (Individualized Education Plan). She reached out to Olaf because, while she used several assessments in her work in literacy, she didn't feel like she had data to understand what students did and did not know in math, especially in the lower grades. As the teacher explained, "There are so many pieces of assessments and benchmarks in terms of reading. The F&P [Fountas & Pinnell] thing is huge! Then math is like, uh I gave them the milestone. It's more hand-wavy. Meanwhile a kid could be mumbling with a group of other kids as they count and doesn't really understand." Beyond interactions about the lack of data, the majority of the eight interactions that composed this enactment of RTN were about the teacher's roles and responsibilities, sharing materials, and logistics of math support (5 of the 8 interactions).

Planning for School Improvement

Approximately 11 percent of the total time I spent observing Liza and Olaf was spent enacting PSI.

With whom? Coaches in Cypress enacted this coaching task with other coaches during team meetings and, at times, with school leaders in their focus schools. Among the four instances of this coaching task, three were enacted with other coaches and one was enacted with a school leader. Generally, Cypress coaches did not interact with school leaders. This was the case even in the six elementary schools that Liza and Olaf were supposed to support in person (i.e., their focus schools). During my time shadowing Liza and Olaf, I observed Olaf interacting with a school leader once and I never observed Liza interacting with a school leader. Olaf explained, "What is unusual in my case is that all my school leaders [i.e., in his focus schools] are math focused and that's not the norm, that's just coincidence." Liza expressed frustration that her emails to her focus schools went unanswered and that generally none of her schools focused on mathematics.

Resources. To enact this coaching task, Liza and Olaf did not use any common district math resources.

Focus. 83 percent of all interactions that composed the enactment of PSI were about the logistics of teacher learning. For example, discussions during elementary math team meetings were commonly about school improvement tasks that needed completed and who would complete them, the mathematics budget for site support, and how to get teachers new manipulatives. Similarly, Olaf's interactions with the school leader were primarily logistical in

nature. Of the eight interactions that constituted Olaf's enactment of this coaching task, six were focused on the logistics of school-based teacher learning. For example, they discussed which teachers have the time and capacity to serve on the school's instructional leadership team, scheduling for assessing students, and the purchase of an external mathematics program for intervention.

District Level Capacity Building

Relative to other coaching tasks, district level capacity building (DLC) consumed the most amount of Cypress coaches' time (27 percent of total time observed).

With whom? Liza and Olaf co-enacted this task with other district math coaches and (at times) other coaches in Curriculum & Instruction.

Resources. No instances of district level capacity building were specifically about mathematics, thus I did not observe coaches using any of the common district math resources.

Focus. None of the interactions that composed the five instances that I observed of this coaching task were math specific. One instance was an induction coach training that Liza was required to attend as part of her induction coaching responsibilities (Olaf was required to attend similar trainings but as part of the district's other induction program). Two instances were planning for the math department's racial-equity meetings. As a reminder, the math department was engaged in self-reflective work where they examined how they re-enacted white dominant culture and how that impacted their relationships in schools and with others in their own department. Finally, two instances were "Professional Growth and Development" (PGD) meetings. PGD meetings were monthly meetings that brought together all of Curriculum

& Instruction (e.g., math, science, English language development, ELA, etc.) for professional development. The executive director of PGD introduced one of the meetings by saying, "Curriculum & Instruction is the heart and soul of what schools are and as district leader in C&I we need to build capacity in order to support schools. What we need to do is find points of collaboration so we can increase coherence…schools are looking to us, they need our guidance around how they are going to serve their students." According to Olaf and Liza, none of the monthly PGD meetings focused on mathematics and they did not find the PGD meetings useful to their work or development. As Olaf explained, "It doesn't feel organic, and it doesn't always feel useful. It feels a little like um, I mean our work in the past didn't feel coherent with our colleagues and it doesn't feel like what we've done on Fridays with PGD has made it any more coherent."

Outward-Facing Tasks

Outward-facing tasks (*henceforth OFT for readability purposes*) was a coaching task that entailed Cypress coaches interfacing with actors from outside the district. This coaching task was unique to Cypress; I did not observe an equivalent task in Almond Valley. I witnessed six instances of OFT (approximately 17 percent of the total observation time).

With whom? Liza and Olaf co-enacted this task with other district math coaches. Liza and Olaf enacted OFT for two primary reasons. One reason was to interface with non-district actors about their curriculum. As a reminder, Cypress developed their own preK-12 mathematics curriculum and district math coaches played a large role in its development and subsequent revisions. As of the 2018-19 school year the Core Curriculum was gaining

prominence outside Cypress and issues surrounding the use of their curriculum outside the walls of the district fell to district math coaches. For example, I observed both Liza and Olaf on a phone call with a principal and vice-principal from San Diego whose elementary school was thinking about adopting the Core Curriculum. In another instance that was curriculum-related, Olaf and another coach met to discuss the possibility of submitting the Core Curriculum to *EdReport*s, an independent nonprofit that reviews the quality of instruction materials to aid practitioners in selection.

Another reason why Liza and Olaf enacted OFT was around planning for conferences. I saw one instance where Liza worked with another coach to write a conference proposal about one of the district's Signature Strategies (i.e., Groupwork Feedback). In another instance Liza worked with other coaches to develop a presentation for a proposal that had already been accepted about how the Core Curriculum supports students with IEPs to access rigorous mathematics.

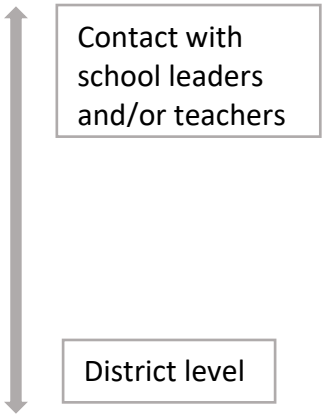
Cross-District Summary

Coaches across both districts enacted or co-enacted five common tasks, including observing and debriefing teachers' instruction, planning and facilitating teacher professional learning, responding to individual teacher needs, planning for school improvement, and building district level capacity. Coaches in Cypress enacted one additional task: outward-facing tasks. While coaches in Almond Valley and Cypress undertook several common coaching tasks, their enactments were different in six key ways:

1. Almond Valley coaches spent more time than Cypress coaches on tasks that reached into schools and classrooms. As shown in Table 16 below, Almond Valley coaches spent relatively more time planning and facilitating teacher professional learning, observing and debriefing teachers' instruction, and responding to individual teachers' needs (accounting for 80 percent of their time). These types of tasks brought them into contact with school leaders and teachers as shown by the arrow to the right of the table that delineates tasks on a spectrum (from those tasks that brought district math coaches together with school leaders and teachers to those tasks that were primarily enacted at the district level away from schools). Although Cypress coaches spent a decent chunk of time planning and facilitating teacher professional learning (24 percent), they also spent far more time than Almond Valley coaches building district level capacity (27 percent) and enacting outward-facing tasks (17 percent). These two tasks accounted for 44 percent of their time while Almond Valley coaches only spent eight percent of their time building district level capacity and did not enact outward-facing tasks.

Table 16. Percent of time coaches in each district spent on each coaching task

Coaching Task	Almond Valley	Cypress
Planning and facilitating teacher professional learning	44%	24%
Observing and debriefing teachers' instruction	23%	13%
Responding to individual teachers' needs	13%	8%
Planning for school improvement	12%	11%
Outward-facing tasks	na	17%
Building district level capacity	8%	27%



2. <u>Almond Valley coaches co-enacted tasks with different role groups more often than Cypress coaches</u>. As shown below in Table 17, coaches in Almond Valley co-enacted two of five coaching tasks with assistant superintendents and/or school leaders. These tasks included planning and facilitating teacher professional learning, and observing and debriefing teachers' instruction. Returning to Table 16 above, you will see that these two tasks accounted for the vast majority of coaches' time in Almond Valley (67 percent). Moreover, both tasks were at the school or classroom levels, settings in which school leaders and assistant superintendents often do not observe or participate. Cypress coaches co-enacted two of seven coaching tasks with school leaders (see Table 17 below), including planning and facilitating teacher professional learning and planning for school improvement. Again, Table 16 above shows that these tasks only accounted for 35 percent of coaches' time. Further, they did not co-enact any of the coaching tasks with assistant superintendents.

Table 17. Who coaches in each district co-enacted tasks with

Coaching Task	**Almond Valley**	**Cypress**
Planning and facilitating teacher professional learning	Other coaches School leaders	Other coaches School leaders
Observing and debriefing teachers' instruction	Other coaches School leaders Assistant Superintendents	Alone
Responding to individual teachers' needs	Alone	Alone
Planning for school improvement	Other coaches	Other coaches School leaders
Outward-facing tasks	na	Other coaches
Building district level capacity	Other coaches	Other coaches

3. Almond Valley coaches leveraged more common district mathematics resources and leveraged them frequently than Cypress coaches. Despite both districts having common district mathematics resources, coaches in Almond Valley were more likely than coaches in Cypress to use the resources in their enactment of coaching tasks. As shown in Table 18 below, in Almond Valley, all but one of the tasks (building district level capacity) made use of district resources, most prominently *Go Math*, the IPG, and the interim assessments. Almond Valley coaches used these resources to guide observations and interactions, align their planning with school and district improvement goals, direct their supports for school improvement, and anchor their professional learning with teachers. In Cypress, coaches only used the Core Curriculum (used in planning and facilitating teacher professional learning, responding to individual teachers' needs, and outward-facing tasks). However, even for these tasks it wasn't pervasive use because not every school used the Core Curriculum.

Table 18. Common district mathematics resources used in each coaching task by district

Coaching Task	**Almond Valley**	**Cypress**
Planning and facilitating teacher professional learning	*Go Math* Quarterly Planner 6-to-8 Week Plan IPG	Core curriculum
Observing and debriefing teachers' instruction	IPG Interim Assessments	None
Responding to individual teachers' needs	IPG *Go Math*	Core curriculum
Planning for school improvement	IPG Interim Assessments	None
Outward-facing tasks	na	Core curriculum
Building district level capacity	None	None

4. In Almond Valley, coaches' interactions with teachers focused on how to use or coordinate instructional materials more often than Cypress coaches' interactions with teachers. In tasks that brought coaches together with teachers, coaches in both districts interacted about some high-depth, substantive issues like instructional practices and student thinking and learning. However, there were also low-depth interactions, about how to use or coordinate instructional materials. I found that in several tasks (including facilitating teacher professional learning, observing and debriefing teachers' instruction, and responding to individual teacher needs), coaches in Almond Valley interacted about how to use or coordinate instructional materials to a higher degree than coaches in Cypress. For example, in Table 19 below you see that 23 percent of the interactions during the facilitation of teacher professional learning in Almond Valley were about how to use or coordinate instructional materials while none of the interactions in Cypress focused on this.

Table 19. Percent of coaches interactions with teachers that focused on how to use or coordinate instructional materials by coaching task

Coaching Task	Almond Valley	Cypress
Facilitating teacher professional learning	23%	0%
Observing and debriefing teachers' instruction	13%	3%
Responding to individual teacher needs	31%	18%

5. <u>During planning for school improvement, Almond Valley coaches' interactions were more likely to focus on instructional practices and student thinking and learning, while Cypress coaches' interactions were more likely to focus on the logistics of teacher learning</u>. As shown in Table 20 below, while planning for school improvement 47 percent of Cypress coaches' interactions were focused on instructional strategies and student learning while none of Cypress coaches' interactions focused on those things. Instead, Cypress coaches focused on the logistics of teacher learning during this coaching task (83 percent) much more than Almond Valley coaches (29 percent).

Table 20. Percent of interactions that focused on instructional practices and student thinking and learning versus logistics of teacher learning while planning for school improvement

	Almond Valley	Cypress
Instructional practices & student thinking and learning	47%	0%
Logistics of teacher learning	29%	83%

6. <u>There was less variability in the nature of coaches' work in Almond Valley as compared to Cypress</u>. By and large, when Laverne and Tallulah worked with school leaders and teachers, they focused on the same improvement priorities; their work was very consistent, structured, and linked to overall district improvement initiatives and resources (i.e., the IPG). This was not the case in Cypress. This contrast is most

exemplified in Liza and Olaf's enactment of facilitating teacher professional learning and observing and debriefing teachers' instruction where the focus of teacher professional learning was determined through individual negotiation between the coach and school leader or the coach and teacher(s).

Chapter 8
How the Design of District Infrastructure Shapes Coaching Practice

Coaching initiatives exist alongside other infrastructure designs meant to guide, support, and improve mathematics instruction across the district. Research on coaching, however, has focused predominantly on coaching as a siloed endeavor or coaching practice as if it exists in a vacuum. District leaders tend to design coaching initiatives without much attention to the ways they are couched within the overall instructional improvement system which often results in initiatives that are layered on top of existing infrastructure designs. In this final chapter of findings, I draw links between the design of each district's infrastructure for elementary mathematics within which these coaches worked (Chapters 5 and 6) and lived coaching practice (Chapter 7). To do this, I exploit the differences in each district's infrastructure along four dimensions (inclusivity, authority, specificity, and alignment) to help explain the differences that emerged between districts in coaches' enactment of various coaching tasks. In doing so, I highlight the potential relationship between coaching practice and the broader infrastructure within which they work.

In the course of this chapter, I elaborate the following argument about the relationship between various dimensions of infrastructure and coaching practice:

1. The alignment and authority of each district's infrastructure combined to shape how coaches spent their time, that is, whether coaches spent more time on tasks that reached into schools and classrooms or whether they spent more time at the district level.

2. The authority of each district's infrastructure shaped the degree to which coaches leveraged common district math resources in the enactment of various tasks.
3. Use of common district math resources and time spent in schools and classrooms combined to shape the degree to which coaches' interactions with other coaches focused on instructional practices and issues of student thinking and learning.
4. The inclusivity of each district's designed infrastructure shaped the degree to which coaches co-enacted tasks with other role groups.
5. Specificity, authority, and alignment of each district's infrastructure combined to shape the degree to which coaches' interactions with teachers focused on how to use or coordinate instructional materials.
6. Specificity, authority, and alignment of each districts' infrastructure combined to shape the variability of coaching practice within each district.

A Quick Review of the Dimensions of Infrastructure

In Chapter 6 I analyzed Almond Valley and Cypress's infrastructures along four dimensions: inclusivity, authority, specificity, and alignment (see Table 21 below for high, medium, or low designations). To quickly review:

Inclusivity. Inclusivity refers to the degree to which the infrastructure provides routinized opportunities for interaction between different role groups on issues of mathematics. Almond Valley's infrastructure had high inclusivity and Cypress's infrastructure had low inclusivity. Looking back to Figures 3 and 4 in Chapter 6, you will see that while both districts designed multiple participation structures for coaches to interact with teachers, only

Almond Valley's infrastructure connected coaches to assistant superintendents and school leaders (i.e., the administrative line). Cypress coaches did participate in coaching assistance with school leaders, but only school leaders in their focus schools, thus they were not connected to most elementary schools.

Table 21. Designations for each dimension of the district infrastructure for elementary mathematics

Dimension	**Almond Valley**	**Cypress**
Inclusivity	High	Low
Authority	High	Low
Specificity	High	Medium
Alignment		
Instructional Materials	Content: High Cognitive Demand: Low	Content: High Cognitive Demand: Medium
Assessments	Content: High Cognitive Demand: Low	Content: High Cognitive Demand: High
School Leader Learning	High	Low
Teacher Learning	High	Medium

Authority. Authority refers to the degree to which the infrastructure is used to monitor or hold school leaders and teachers accountable to the district's student learning goals and instructional vision in mathematics. Almond Valley's infrastructure had high authority while Cypress's infrastructure had low authority. In Almond Valley, student and teacher data were regularly collected to, in part, monitor student learning and teaching practice. *Go Math* was mandated, and its use was monitored by school leaders and assistant superintendents. Teachers were also held accountable for implementing practices that they learned about in professional learning. In Cypress, student data were collected but there were no expectations for their use. No instructional data were collected. The Core Curriculum was not mandated and there was no follow-up to teacher professional learning.

Specificity. Specificity refers to the degree to which the infrastructure provides clear and detailed guidance about what to teach and how to teach it. Almond Valley's infrastructure had high specificity and Cypress's had medium specificity. Two key differences in specificity warranted these designations. First, Almond Valley's curriculum specified a detailed route to reach the student learning goals of the lesson while Cypress's did not. Second, the IPG in Almond Valley specified what a high-quality mathematics classroom should look like while Cypress did not have an equivalent specification.

Alignment. Alignment refers to the degree to which there are coherent connections between different components of the infrastructure and the student learning goals or the instructional framework. Teacher and school leader learning were well-aligned with the district's instructional framework in Almond Valley (see the bottom two rows of Table 21 above). That is, teacher and school leader learning structures consistently focused on supporting teachers and school leaders to learn to implement the district's vision for mathematics instruction laid out in the IPG. In Cypress, school leader learning was not aligned with their instructional framework and only some teacher learning structures were aligned (low and medium alignment respectively). While Cypress's school leader and teacher learning systems were low to moderately aligned, their instructional materials and assessments were well-aligned with the CCSS-M both in content and cognitive demand (see instructional materials and assessments rows of Table 21). The content of Almond Valley's instructional materials and assessments were well-aligned with the CCSS-M, but the cognitive demand was not. That is, the

tasks in the curriculum and assessments did not provide students the opportunity to engage in the kinds of mathematical thinking and problem solving that are called for in the CCSS-M.

Given these differing profiles of inclusivity, authority, specificity, and alignment, the rest of this chapter is concerned with how different dimensions or combinations of dimensions within each district may account for or appear to influence the observed differences in coaching practice.

Explaining Differences in Coaching Practice in Almond Valley and Cypress

Alignment and authority combined to shape how coaches spent their time. Almond Valley coaches spent more of their time enacting tasks that brought them into schools and classrooms. Most of their time was spent observing and debriefing teachers' instruction and planning and facilitating teacher professional learning. Cypress coaches spent less time in contact with teachers and school leaders, instead spending relatively more time building district level capacity and engaging in outward-facing tasks. Here I argue that the relative balance in time coaches spent on various coaching tasks can be accounted for by the different levels of alignment and authority of each district's infrastructure.

In Almond Valley, school leader and teacher learning were well-aligned with the district's vision for mathematics instruction (i.e., the IPG). Coaches, the math content specialists in the district, were utilized and well-integrated into these learning systems. For instance, coaches enacted classroom walkthroughs with school leaders and assistant superintendents and provided monthly professional learning to teachers. Coaches also provided ongoing coaching assistance to small and large groups of teachers in schools based on need. School

leaders were given consistent messaging that if their school's data indicated that teachers needed support in mathematics, they could reach out to the district math coaches. School leaders were also often directed to reach out to district math coaches by their assistant superintendent. As Tallulah described, "If their principal doesn't reach out to us or doesn't request, we [district math coaches] don't go insert ourselves. [Chuckles] Often things come from a level above principals. For example, the superintendent will be like, 'You're [coaches] going to help this school.'" During the 2018-19 school year assistant superintendents were especially focused on improving mathematics teaching and learning across the district so directives from above occurred frequently. Here, one assistant superintendent described this push:

> I sell them [district math coaches] to schools, meaning I'm workin' with you as a principal and I'll say, 'Hey, have you reached out to math?' 'Hey, I just walked your fourth-grade classrooms. Have they gotten any professional learning from math coaches?' 'Oh, no?' 'Okay. Why don't you reach out?' Then there's a little form they fill out and they get a math coach.

Thus, when district math coaches in Almond Valley entered schools, it was often with the backing of assistant superintendent's authority. These circumstances (i.e., well-aligned school leader and teacher learning systems and high authority from assistant superintendents) combined to influence the large (relative to Cypress) amount of time coaches spent engaging in the two coaching tasks that most often brought them into contact with school leaders and teachers: observing and debriefing teachers' instruction and planning & facilitating teacher professional learning.

On the flip side, Cypress's teacher learning was moderately aligned with the CCSS-M and their school leader learning was not aligned at all. Because neither teacher learning nor school leader learning were consistently focused on mathematics, coaches were not utilized in schools and classrooms to the same degree as Almond Valley coaches. For example, in one structure for teacher learning, induction coaching, district math coaches were utilized, but not always for mathematics (i.e., they engaged teachers in literacy coaching cycles). Coaches also had difficulty accessing even the few schools they were assigned to support in-person (i.e., their focus schools), due, in part, to the lack of authority behind the district math department's priorities. More specifically, assistant superintendents (those with authority over school leaders) did not push school leaders to focus on mathematics improvement during the 2018-19 school year. As Liza explained:

> I still feel like there's not emphasis on math from the district. There's a lot of emphasis on literacy— The schools we go to, we want each school to have two teacher leaders to support math planning and build teacher capacity to lead and stuff and not always rely on people like me and Olaf and whatever. You go to—take Davis Elementary for example. I can identify the literacy team, but to this day still, we are in October now, October 19th, who are your two teacher leaders for math? It's just not—it's not a priority. It's not a focus. I feel, if a school feels that way, it's because the district isn't placing that emphasis on math…you also barely see math in PD plans for schools.

This perception held true in Liza and Olaf's focus schools. Of the six focus schools that Liza and Olaf supported, only one focused their improvement efforts on mathematics teaching and learning during the year of this study. Davis Elementary, for example, was one of the schools that Liza was supposed to provide support to, but the principal at Davis focused their improvement efforts on Balanced Literacy so they rarely reached out to Liza for support and

Liza had a hard time inserting herself into the school's supports for teachers (no one would respond to her emails). In the one school that was focused on mathematics (Paul Robeson Elementary), Olaf had an easier time gaining access. Overall, these circumstances combined to shape the type of tasks Cypress coaches spent most of their time on, that is, with little access to schools due to low alignment and authority, coaches spent relatively more time on tertiary tasks or tasks that were not directly a part of the instructional improvement system such as building district level capacity and outward-facing tasks.

Authority shaped coaches use of common district math resources. While enacting various coaching tasks, authority shaped the degree to which coaches leveraged common district math resources. Almond Valley coaches used more common district math resources and used them more often than Cypress coaches. These resources most prominently included the IPG (or data from the IPG), *Go Math*, and data from the interim assessments. Cypress also had common district math resources, including the Core Curriculum, the Math Teaching Toolkit, and the Milestone assessments. What can account for their limited use? I argue that in Almond Valley, common district math resources were backed by authority thereby explaining their prevalent use among coaches. In Cypress, resources were not backed by authority and thus played a limited role in coaches' improvement efforts.

In Almond Valley, the IPG was used on a regular basis to collect instructional data and monitor instruction across the district. District and school leaders as well as coaches were in and out of classrooms all the time, usually with the IPG in hand. When asked what specifically she looked for when observing teachers' instruction, Laverne replied, "We use the IPG 'cause

that's what's supposed to guide everyone about what best practices should look like and could look like." Indeed, any time I observed either Tallulah or Laverne observing instruction they used the IPG (I saw it used during the enactment of both observing and debriefing teachers' instruction and responding to individual teacher needs). Scores on the IPG were also the primary method through which the district determined whether, or to what extent, teachers' instruction was aligned to instructional shifts called for in the CCSS-M. Accordingly, I found that coaches used the IPG while planning for teacher professional learning and planning for school improvement, that is, two coaching tasks they enacted to ensure that their designs or plans for teacher learning (or other forms of school support) would (at least theoretically) bring teachers' instruction into closer alignment with the CCSS-M and raise scores on the IPG for future district monitoring efforts.

In addition to teachers' instruction, student learning was monitored by the district through thrice-yearly interim assessments. According to coaches, school leaders and teachers recognized these assessments as high stakes. Coaches also took these assessments seriously as evidenced by the fact that they incorporated interim scores into their decision-making process for school supports and teacher learning. I observed coaches using interim scores during their enactment of both observing and debriefing teachers' instruction and planning for school improvement; in the former they used student scores on interims to direct them to schools that needed support. In the latter they used student scores on the interims to add context to the IPG data they had collected during classroom walkthroughs to make decisions about the nature and content of teacher supports at the school. *Go Math*, another common district math

resource utilized by coaches, was mandated in Almond Valley, and assistant superintendents and school leaders monitored its use. Coaches accordingly anchored all their teacher professional learning and coaching assistance with material from the curriculum. Indeed, I observed coaches using *Go Math* while planning for and facilitating teacher professional learning and responding to individual teacher needs.

Cypress also had common district math resources, but they were not backed by authority, shaping their limited use among coaches. The Core Curriculum was not mandated. School leaders were able to make choices regarding the mathematics curriculum that their teachers used, and a fair number of schools were increasingly moving away from the Core Curriculum. As Liza explained, “Schools are not using our Core Curriculum. It's hard to go into a school and say, you have to use it. As a coach, I don't have that status. Yeah. I just don't have that—I'm not an admin or anything.” Accordingly, the only tasks where coaches interacted with teachers in which I observed them using the Core Curriculum was planning and facilitating teacher professional learning and responding to individual teachers’ needs. However, its use in the enactment of these tasks was either limited or surface-level. That is, the only teacher professional learning that was tied to the curriculum was the new teacher professional learning sessions. The other centralized professional learning (teacher leader trainings) was not anchored in the curriculum, and induction, Lesson Study, and other forms of school level support were hit and miss depending on whether the school was using the Core Curriculum.

Milestone assessments were collected by the district, but their use was inconsistent; some assistant superintendents used those data with the principals they supervised, others did

not. Neither Liza nor Olaf were able to articulate how the data were used by the district and neither of them used the data in their work. Finally, I did not see either Liza or Olaf use or even refer to the Math Teaching Toolkit in their practice.

The differing circumstances of resource use between coaches in Almond Valley and coaches in Cypress confirms a point that scholars have theorized regarding the authority of district infrastructure. That is, school and district leaders are unlikely to engage with the infrastructure in productive ways if they don't perceive it as something they should take seriously. Without the backing of authority in Cypress, common district mathematics resources like the Core Curriculum and Milestones were not engaged with seriously by teachers and school leaders. Thus, even if coaches (who engaged with these resources because of their position in the district math department) took the use of the instructional materials and assessments seriously, they did not pick up and use them in interactions with any consistency because those they were interacting with did not view those resources in the same way.

Use of common district math resources and time spent in schools and classrooms combined to shape the focus of coaches' interactions with other coaches. During the enactment of planning for school improvement, Almond Valley coaches' interactions were much more likely to focus on instructional practices and student thinking and learning as compared to Cypress coaches' interactions (47 percent and 0 percent). In Cypress, coaches were more likely to talk about logistics of teacher learning as compared to Almond Valley coaches (83 percent and 29 percent). Here I argue that Almond Valley coaches' use of common district math resources, specifically the IPG, as well as the fact that they spent more time in schools and

classrooms than Cypress coaches, led to interactions among coaches that centered squarely on teaching and learning. Cypress did not have a resource akin to the IPG and had difficulty gaining access to schools and classrooms, so they had no way of anchoring their interactions to substantive issues such as instructional practices and student thinking and learning.

In both districts, most coach-coach interactions happened in coach team meetings during which coaches took stock of where they were and planned for "next steps." Despite similar task structures, the discussions that occurred during these meetings were very different across the two districts. In Almond Valley, the discussions were anchored in the coaches' IPG reports that they completed after observing instruction in classrooms (and as already established they were in classrooms a lot). In fact, coaches always used the IPG while enacting planning for school improvement. I never observed an instance of this coaching task where the IPG was not used. Triston, the elementary math manager, described the importance of the IPG while planning for school improvement when he said, "I think the IPG helps quite a bit. You can call out aspects of the IPG and those are understood. Just the level of specificity it brings. We [all the coaches] don't all get to walk classrooms together or observe practices together so having the IPG helps during planning conversations."

In Cypress there was no district resource akin to the IPG to guide coaches' classroom observations and subsequent interactions while enacting the coaching task of planning for school improvement. Beyond this, coaches were rarely in teachers' classrooms (the exception being their induction teachers). Thus, when coaches sat down to talk amongst themselves and

plan for their improvement work in schools, they typically deferred to talking more about logistics and coordination issues.

Inclusivity shaped the degree to which coaches co-enacted tasks with other role groups. Almond Valley coaches co-enacted tasks with different role groups more often than Cypress coaches. I argue this can be explained by the various designed opportunities for coaches to interact with other role groups in Almond Valley's infrastructure (high inclusivity) and the dearth of such opportunities in Cypress (low inclusivity).

Almond Valley's infrastructure had high inclusivity, that is, coaches had several designed opportunities to interact with other role groups. In my observation of coaching practice in Almond Valley, I found that coaches took advantage of these opportunities. More specifically, I found that Almond Valley coaches were more likely than Cypress coaches to co-enact tasks with professionals in the administrative line; three of the five coaching tasks (observing and debriefing teachers' instruction, planning & facilitating teacher professional learning, and building district level capacity) were co-enacted with school leaders and/or assistant superintendents, accounting for 75 percent of their time. Cypress's infrastructure, on the other hand, had low inclusivity. Coaches had no opportunities to interact with assistant superintendents and very limited opportunities to interact with school leaders. In my observations of coaching practice in Cypress, I found that only two of the seven tasks (planning for school supports and planning for school improvement) were (at times) co-enacted with school leaders (and only leaders from focus schools). These tasks accounted for only 33 percent of coaches' time.

Specificity, authority, and alignment combined to shape the focus of coaches' interactions with teachers. Across the two districts there were some commonalities regarding what coaches talked about with teachers (instructional strategies and student thinking and learning). However, one notable difference between the two districts was the proportion of interactions between coaches and teachers that focused on how to use or coordinate instructional materials. I found that Almond Valley coaches' interactions with teachers focused on how to use or coordinate materials more often than Cypress coaches' interactions with teachers. I argue that different profiles of specificity, authority, and alignment between Almond Valley and Cypress shaped what coaches talked about with teachers. More specifically, the highly specified curriculum in Almond Valley that was misaligned with the CCSS-M, combined with the way the district monitored the curriculum's use explained, in part, why coaches spent more time with teachers helping them understand "the right way to use it." In Cypress, the curriculum was not highly specified, and it was well-aligned with the CCSS-M. These attributes, combined with the fact that the district did not mandate the curriculum or monitor its use, played a role in coaches limited number of conversations with teachers about how to use or coordinate instructional materials.

Almond Valley's infrastructure had high specificity. A key component of this highly specified infrastructure was their curriculum (*Go Math).* The curriculum was made up of many mathematical tasks that were broken down into a series of manageable steps that—if executed properly by the teacher—would lead students to the learning goals of the lesson. In this way, the curriculum provided (or gave the illusion of providing) a foolproof learning trajectory for

students. In addition to the core text, *Go Math* offered other supplements such as *Grab and Go* which were math centers that could be used for differentiation or various digital components such as the *Personal Math Trainer, Interactive Student Edition,* and *Math on the Spot* videos. All this suggested that there was a right and wrong way to use the curriculum and that teachers needed to understand the right way to successfully enact the curriculum. I found that support in this respect often fell to coaches. For example, at the end of one teacher professional learning session I observed, teachers were supposed to plan a portion of a lesson with the support of coaches, incorporating some of the pedagogies they had just learned about. Instead of planning, interactions tended to be about when to use supplemental pieces of the curriculum despite coaches trying their best to keep teachers on task. This was a common occurrence in many of the teacher professional learning sessions I observed.

In addition to the highly specified curriculum and various components that all had to be put together like a puzzle to function properly, coaches had to contend with the fact the cognitive demand afforded through the tasks found in the curriculum was misaligned with the CCSS-M. To their credit, coaches recognized this weakness in their curriculum and worked with teachers to make sense of this misalignment. I found that this work often involved little tips and tricks to bring the curriculum and standards into closer alignment. For example, I observed coaches telling teachers to only let students see singular tasks at a time to prevent their learning from being over-scaffolded. I also observed coaches talking with teachers about timing various portions of the lesson or being strategic about the tasks that students work on (i.e.,

picking the task that most closely aligns with the primary standard) to ensure that they had time to get to the higher cognitive demand tasks that often came later in the lesson.

Turning to Cypress, Cypress's infrastructure had high alignment, low specificity, and low authority. While the curriculum was well-aligned with the CCSS-M, it was not structured to direct students through a pre-determined learning pathway; instead, students were expected to problem-solve how to solve "meaty" tasks in collaboration with their peers and with scaffolding by the teacher (without the teacher taking over the task and showing them how to do it). Teachers were not required to use the curriculum or use it in specific ways. Indeed, the math department frequently argued that there was no "right way" to implement the Core Curriculum. Instead, the curriculum relied on teachers' understanding of the mathematics, and their students' current mathematical understandings to successfully implement the curriculum. Perhaps because the curricula was well-aligned, the coaches did not spend time talking to teachers about little "tips and tricks" to bring the curriculum into better alignment like coaches in Almond Valley. Because there was the belief that there was no one right way to use the curricula and, indeed, limited pressure to use the curriculum at all much less in specific ways, coaches did not focus much time on how to use or coordinate instructional materials in their interactions with teachers. Because the district did not monitor teachers' use of the curriculum, coaches were also free to work on deeper enactments of the curriculum that were not as easily monitored for compliance.

Specificity, authority, and alignment combined to influence coaching variability. Overall, Almond Valley coaches' work across the district was very consistent, structured, and linked to

district improvement initiatives whereas coaches' work in Cypress tended to be school and teacher specific and tenuously linked to district improvement initiatives. Tallulah and Laverne, for the most part, did the same things whereas Olaf and Liza did not. I argue this can be accounted for through the different profiles of specificity, authority, and alignment in each district.

The profile of dimensions in Almond Valley pushed coaches to act in systemic ways. Specificity, as outlined in the IPG and the interims, guided almost everything that coaches did. The IPG provided a lens through which coaches observed instruction and focused their interactions with other role groups in the district. Both the IPG and interims then supported coaches' decision-making about instructional supports. Other components of the infrastructure were aligned with the IPG. Most importantly, school leader learning was aligned, which meant that school leaders were knowledgeable about the district's vision for mathematics and therefore primed for work that district coaches engaged in at their school. Indeed, in my observations of coaches work in schools, everything was anchored by the IPG. Authority also prompted coaches to act on behalf of the district as a whole. The expectation was that teachers worked to align their instruction with the IPG, and it was the coaches' role to help them achieve that alignment. This meant that even when coaches worked with individual teachers (such as when they responded to individual teacher needs), they consistently focused on practices called for in the IPG as opposed to stuff the teacher or school leader wanted to focus on or even the coaches own personal persuasions. Finally, the fact the curriculum was mandated played a role in the lack of coaching variability. Because all teachers were expected to be

teaching from the curriculum and this was monitored, coaches rarely, if ever, went into a school and met with a teacher who were not teaching from the curriculum.

On the other hand, the profile of dimensions in Cypress steered coaches towards individualized improvement needs. Expectations for how to teach mathematics were not specified so coaches were not guided toward common district ends in their work with teachers. The district also prioritized school autonomy, letting school leaders make decisions that they thought were best for their staff and students. If coaches worked in schools, the focus of their work was determined through individual negotiation with school leaders, thus contributing to variability. All-in-all coaches work in Cypress was somewhat ad hoc and tenuously linked to mathematics teaching and learning. Hence what coaches noticed, paid attention to, and ultimately talked about in their interactions was often determined by personal preferences or current demands of the context.

Chapter Summary. The dimensions of each district's infrastructure appeared to shape coaching practice in several ways, including how coaches spent their time, the extent to which they used common district math resources, who they interacted with, the focus of their interactions with teachers and with one another, and the variability between coaches within the same district.

These findings suggest that the dimensions have far-reaching consequences ranging from who interacts with whom all the way down to what they talk about in those interactions. The findings also suggest the infrastructure dimensions act both alone and (more frequently) in

concert with one another. This suggests that the influences of the dimensions are intertwined, and that it is the profile of dimensions that matters in shaping what coaches do.

Chapter 9
Conclusions and Implications

Coaching has emerged at the "strategy du jour" (Coburn & Russell, 2008, p. 224) in school and district efforts to improve instruction. Indeed, district leaders across the country are spending thousands of dollars each year designing and implementing large-scale coaching initiatives. This comes on the heels of an accumulation of research pointing to the potential value of coaching (Biancarosa, Bryk, & Dexter, 2010; Correnti et al., 2021). However, research has also not kept pace with the realities on the ground. Despite the accumulation of evidence that coaching can "work," there is also a bulk of inconclusive evidence (Garet et al., 2008). Moreover, even when studies show positive outcomes of coaches (e.g., improved teacher and/student learning), it is often not clear what features of coaching were responsible for those outcomes. The few in-depth studies that exist suggest that what takes place in the name of coaching varies from site to site and sometimes teacher by teacher. All of this suggests the need for more careful research on what coaches actually do.

We are beginning to understand more about the processes of coaching, including the roles and responsibilities they typically take on. These studies, however, treat coaching as if coaches work in a vacuum (Neumerski, 2012). Some scholars have taken up research that identifies school and district conditions that facilitate coaching (Huguet, Marsh, & Farrell, 2014), but this research tends to view these features as a static backdrop (or as conditions that must be met), not as an integral component of coaching (Neumerski, 2012). Very few studies recognize coaching practice as constituted in the day-to-day interactions between coaches and others as they carry out a plethora of tasks related to instructional improvement. Indeed,

coaches' interactions with other components of the larger improvement system may have important implications for the success or failure of coaching initiatives. Despite researchers' increased ability to list or articulate what coaches do and even some research that has been able to make claims about behaviors or conditions that lead to greater coaching effectiveness, the field lacks a robust understanding of coaching beyond a siloed- endeavor or theories of coaching as one aspect of a district's infrastructure for instructional improvement (Hopkins et al., 2013).

This dissertation study engaged seriously with this gap in the literature, that is, the relationship between coaches' practice and broader infrastructures for instructional improvement. I studied this relationship in the context of elementary mathematics. To explore this relationship, I conceptualized coaching as a distributed practice. In this conceptualization, coaching is "stretched over" the broader infrastructure that includes other instructional leaders, participation structures, and resources that together as a unit work to coordinate, maintain, and improve instruction. This conceptualization privileged interactions between coaches and others that were mediated by the designed infrastructure for elementary mathematics.

I found that Almond Valley and Cypress adopted similar visions for students' mathematical learning and instruction. To achieve these visions, both districts designed infrastructure to guide and support school leaders and teachers as they endeavored to improve elementary mathematics teaching. These designed infrastructures included formal role groups that were designed to engage in issues of instructional improvement, resources designed to

"carry" the district vision to various communities across the district (including instructional frameworks and materials and assessments), and designed participation structures for various role groups to participate in learn about the district vision for mathematics teaching and learning. Coaches were a key component in both districts' infrastructures.

While Almond Valley and Cypress infrastructures looked similar in terms of their component parts, I showed that the districts made different strategic choices. These choices diverged along four dimensions: inclusivity, authority, specificity, and alignment. I found that Almond Valley's designed infrastructure had high inclusivity, authority, and specificity. Regarding alignment, I found that school leader and teacher learning was well-aligned, but the instructional materials and assessments were not. Cypress's infrastructure, on the other hand, had low inclusivity, low authority, and medium specificity. Regarding alignment, I found that school leader learning was misaligned, and teacher learning was moderately aligned. For the most part, instructional materials and assessments were also well-aligned.

Given these characterizations of each district's designed infrastructures, I then zoomed in on coaching practice, that is, how district math coaches in these two districts worked in and through the designed infrastructures. I showed that across districts, coaches engaged in five common coaching tasks: 1) planning and facilitating teacher professional learning, 2) observing and debriefing teachers' instruction, 3) responding to individual teacher needs, 4) planning for school improvement, and 5) building district level capacity. Coaches in Cypress also enacted one other task: outward-facing tasks. Despite these similar tasks, I dug deeper to show that their enactments were different in several consequential ways: 1) how they divided time

among various tasks, 2) what resources they used and how, 3) who they co-enacted tasks with, 4) the degree to which their interactions with one another focused on instructional practices and student thinking and learning, 5) the degree to which their interactions with teachers focused on how to use and coordinate instructional materials, and 6) the variability of coaches' practice within each district.

Finally, I explained these variations in task enactment by pointing to the ways inclusivity, authority, specificity, and alignment of the designed infrastructures shaped coaches' lived practice. To do this, I exploited what I established earlier in the dissertation regarding the differing profiles of these dimensions in each district. More specifically, I found:

1. The alignment and authority of each district's infrastructure combined to shape how coaches spent their time, that is, whether coaches spent more time on tasks that reached into schools and classrooms or whether they spent more time at the district level.
2. The authority of each district's infrastructure shaped the degree to which coaches leveraged common district math resources in the enactment of various tasks.
3. Use of common district math resources and time spent in schools and classrooms combined to shape the degree to which coaches' interactions with other coaches focused on instructional practices and issues of student thinking and learning.
4. The inclusivity of each district's designed infrastructure shaped the degree to which coaches co-enacted tasks with other role groups.
5.

6. Specificity, authority, and alignment of each district's infrastructure combined to shape the degree to which coaches' interactions with teachers focused on how to use or coordinate instructional materials.
7. Specificity, authority, and alignment of each districts' infrastructure combined to shape the variability of coaching practice within each district.

Study Limitations

This dissertation foremost seeks to understand the relationship between designed district infrastructure and lived coaching practice. To do this, I directly observed coaches during two observation windows. While I worked with coaches to schedule these observation windows during days that best represented their normal workflow, only a pure ethnography (i.e., extended observation) can elicit data that represents both the breadth and depth of coaches' work. Indeed, from interviews with coaches in both districts, I learned about coaching tasks (e.g., co-planning lessons with teachers) that I never observed. Descriptions of these coaching tasks from interviews did not provide me with the level of detail necessary for my analysis of the nature of interactions so I did not include them in my findings.

A second limitation of this study is related to my methods for designating high, medium, and low for each dimension of infrastructure. This type of qualitative scaling is most accurate when there is a larger sample so the researcher can better define the boundaries between low and medium, and from medium and high. With a sample size of two districts, I was left with establishing these designations as relational to one another. For example, Almond Valley's infrastructure had high authority as compared to Cypress, but with a larger sample of districts I

may have deemed Almond Valley as medium authority because there were circumstances in other districts that made them higher authority than Almond Valley. Where possible, I attempted to alleviate this limitation by leveraging how the literature conceptualizes these dimensions, trying to align my designations with their descriptions.

Contributions to Research

This dissertation contributes to the body of research on coaching in three ways. To my knowledge, this study is the first to conceptualize coaching as a distributed practice (Spillane, 2006). This conceptualization broadens our notions of coaching practice beyond the individual coach and their knowledge, beliefs, and actions to coaches in interaction with others and the cultural and material artifacts in particular situations. In this study, I treated the coaches' situation as the district infrastructure for elementary mathematics. This allowed me to advance the study of coaching beyond looking at coaching as a siloed endeavor to one in which coaching is constituted in the fields of interaction between and among the coach, other district leaders, participation structures, and common resources.

To date, most of the research on infrastructure has identified the dimensions that I used here (i.e., inclusivity, authority, specificity, and alignment) as important considerations for practice. While most of these studies identified singular dimensions and their influence on practice, I present a typology of four dimensions, showing how they interact and shape practice in consequential ways. Further, studies of infrastructure tend to look at its effect on teaching practice; this study adds to the few studies that examine how infrastructure shapes coaching practice.

It is not unusual for studies of coaching to identify tasks that coaches commonly undertake. I did that here as well. However, where the other studies stop at the point of describing those tasks, I looked more deeply in an empirical and systematic way at the interactions that comprised the task. In so doing, I uncovered differences that may be overlooked in studies that stay at the level of describing tasks. For example, I found that coaches in both districts enacted the task of planning for school improvement. While the general structure of the task was the same, I found that interactions that constituted the task were very different: Almond Valley coaches talked about teaching and learning and talk in Cypress was dominated by discussion of logistics and coordination.

Implications for District Leaders

My findings also have implications for district leaders that have a cadre of coaches at the district level. First, my findings suggest that district leaders could benefit from acknowledging the unique circumstance that coaches who work at the district level present. District coaches are not school-based coaches. School-based coaches are in the same school every day and can more easily embed themselves into the inner workings of the school. In the case of district coaches, special care must be taken to ensure that there are designed mechanisms to integrate district coaches into schools. As we saw in Almond Valley, classroom walkthroughs brought district coaches into schools on a regular basis. Often, next steps emerged from those walkthroughs that brought coaches back into schools to facilitate some sort of professional learning with teachers, to help a school leader design a professional learning, or to coach a grade-level PLC of teachers. There were also more authoritative

mechanisms that brought coaches into schools. Those with authority in the district backed a set of priorities around mathematics instructional improvement. Assistant superintendents often pressed school leaders to invite district math coaches into their schools based on their own walkthroughs and looking at data.

In Cypress, on the other hand, coaches had difficulty accessing even the few schools that they were assigned to support. Without authoritative press behind improving mathematics instruction at the district level, leaders in these schools tended to focus their energy on literacy and kept district math coaches at arms-length. Cypress also did not have designed participation structures to bring district coaches into schools beyond induction. Indeed, in Cypress, other designs for participation such as new teacher PLs and teacher leader trainings were centralized learning structures at the district level. Other school level work such as Lesson Study and other forms of coaching had to be negotiated with the school leader. Overall, district leaders could benefit from an understanding that the design of coaching must be integrated with other components of the infrastructure and backed by some form of authority if they are to successfully penetrate schools.

Second, the design of resources in the infrastructure needs to take into consideration more than the resources themselves. No matter how well-designed or widely shared or aligned, those resources will not be taken up and used without press from district leaders. Indeed, in Almond Valley where authority was high, coaches consistently used resources. They used the interim assessment because the district monitored student learning using them. The consistently used the curriculum because it was mandated. And, they consistently used the IPG

because it embodied what leaders would be looking for in math classrooms. The lack of press behind the set of resources in Cypress meant that there was little or no use of resources.

Third, curriculum and other resources that are highly specified present a double-edged sword. On the one hand, they can be a helpful scaffold for inexperienced teachers as well as the coaches they work with. On the other hand, in environments characterized by high authority and misalignment, coaches can end up talking about the right way to use those materials instead of deeper enactments of the curriculum that are not as easily monitored for compliance.

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Appendix A
Definitions of Key Dimensions of Infrastructure

Table 22. Definitions of key dimensions of infrastructure

Dimension	Definition
Inclusivity	The degree to which the infrastructure provides routinized opportunities for interaction between different role groups on issues of mathematics.
Low	An infrastructure is considered to have low inclusivity if there is at least one routinized opportunity for interactions between elementary math coaches and one or fewer other role groups.
Medium	An infrastructure is considered to have medium inclusivity if there is at least one routinized opportunity for interaction between elementary math coaches and two other role groups.
High	An infrastructure is considered to have high inclusivity if there is at least one routinized opportunity for interaction between elementary math coaches and three or more different role groups.
Authority	The degree to which the infrastructure is used to monitor or hold school leaders and teachers accountable to the district's student learning goals and instructional vision in mathematics.
Low	An infrastructure is considered to have low authority if there is complete or near complete autonomy on the part of teachers and/or school leaders. This includes a lack of district mandates and mechanisms of monitoring or accountability.
Medium	An infrastructure is considered to have medium authority if there are some district mandates accompanied by moderate accountability. Moderate accountability is defined as accountability in at least one sphere of activity (e.g., instructional practices) or accountability that waxes and wanes over the course of the school year.
High	An infrastructure is considered to have high authority if there are district mandates accompanied by high accountability. High accountability is defined as accountability in two or more spheres of activity.
Specificity	The degree to which the infrastructure provides clear and detailed guidance about what to teach and how to teach it.
Low	An infrastructure is considered to have low specificity if one or none of the following are clear and detailed: content, learning goals, route to reach the learning goals, and instructional strategies.
Medium	An infrastructure is considered to have medium specificity if two or three of the following are clear and detailed: content, learning goals, route to reach the learning goals, and instructional strategies. Also at least one of the following: pacing and sequencing, timing of different parts of a lesson,

	models, representations, and tools to use or have available for students to self-select.
High	An infrastructure is considered to have high specificity if all four of the following are clear and detailed: content, learning goals, route to reach the learning goals, and instructional strategies. Also at least one of the following: pacing and sequencing, timing of different parts of a lesson, models, representations, and tools to use or have available for students to self-select.
Alignment	The degree to which there are coherent connections between different components of the infrastructure and the student learning goals or instructional framework.
Instructional Materials	
Content	
Low	Instructional materials are considered to have low alignment in content when 79% of the standards or below are covered.
Medium	Instructional materials are considered to have medium alignment in content when 80-90% of the standards are covered.
High	Instructional materials are considered to have high alignment in content when all standards are covered.
Cognitive Demand	
Low	Instructional materials are considered to have low alignment in cognitive demand if the majority of grade levels do not include activities at one or more of the cognitive demand levels.
Medium	Instructional materials are considered to have medium alignment in cognitive demand if the majority of grade levels had a balance of two out of the four levels of cognitive demand.
High	Instructional materials are considered to have high alignment in cognitive demand if the majority of grade levels had a balance of three out of the four levels of cognitive demand.
Assessments	
Content	
Low	Assessments are considered to have low alignment in content with the curriculum when the overlap between topics covered by the assessment and the curriculum was less than 50 percent for the majority of grade levels.
Medium	Assessments are considered to have medium alignment in content with the curriculum when the overlap between topics covered by the assessment and the curriculum was between 50 and 75 percent for the majority of grade levels.

High	Assessments are considered to have high alignment in content with the curriculum when the overlap between topics covered by the assessment and the curriculum was at least 75 percent for the majority of grade levels.
Cognitive Demand	
Low	Assessments are considered to have low alignment in cognitive demand with the curriculum when the percentages of three out of the four levels of cognitive demand were greater than 20 percentage points from each other.
Medium	Assessments are considered to have medium alignment in cognitive demand with the curriculum when the percentages of three out of the four levels of cognitive demand were within 10-20 percentage points of each other.
High	Assessments are considered to have high alignment in cognitive demand with the curriculum when the percentages of three out of the four levels of cognitive demand were within 10 percentage points of each other.
School Leader Learning	
Low	School leader learning is considered to have low alignment when there is a lack of focus on mathematics or when the focus is on general instructional strategies absent specific references to content.
Medium	School leader learning is considered to have medium alignment when there is a moderate focus on mathematics and when there is a moderate focus on the core instructional practices called for in the instructional framework or standards.
High	School leader learning is considered to have high alignment when there is a strong focus on mathematics and when there is a consistent focus on the core instructional practices called for in the instructional framework or standards.
Teacher Learning	
Low	Teacher learning is considered to have low alignment when there is a lack of focus on mathematics or when the focus is on general instructional strategies absent specific references to content (e.g., how to structure the lesson to better differentiate instruction).
Medium	Teacher learning is considered to have medium alignment when there is a moderate focus on mathematics and when there is a moderate focus on the core instructional practices called for in the instructional framework or standards.
High	Teacher learning is considered to have high alignment when there is a strong focus on mathematics and when there is a consistent focus on the

	core instructional practices called for in the instructional framework or standards.

Appendix B
Definitions of Levels of Cognitive Demand

Table 23. Levels of cognitive demand and definitions

Level	Definition
1. Recall/reproduction	Task requires recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula. The task is a one-step, well-defined procedure. The task has students demonstrate a rote response, perform a well-known task, or follow a set procedure.
2. Application of concepts	Task requires noticing or describing non-trivial patterns, explaining the purpose and use of experimental procedures; carrying out experimental procedures; making observations and collecting data; classifying, organizing, and comparing data. The task has students make some decisions as to how to approach the problem or activity. Actions may take more than one step.
3. Strategic thinking	Task requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. In most instances, a task that has more than one possible answer, requires students to explain their thinking or make conjectures is at Level 3. Generally, the cognitive demands are complex and abstract because the task requires more demanding reasoning.
4. Extended thinking	Task requires complex reasoning, planning, developing, and thinking, most likely over an extended period of time. The cognitive demands of the task should be high and the work should be very complex. For example, students should be required to make several connections, relate ideas within the content area or among content areas, and have to select one approach among many alternatives on how the situation should be solved.
NEI	When not enough information was available to decipher what the task demanded of students' thinking processes or engagement, we coded the item NEI. (See Appendix, Table A2, for NEI examples.)

Appendix C
Focus of Coaches' Interactions

Table 24. Focus of coaches' interactions during planning for teacher professional learning

Focus of Interaction	Almond Valley	Cypress
Design of teacher PL activities, including a discussion of why	65%	67%
How to use or coordinate instructional materials	22%	0%
Logistics of teacher learning	13%	33%
	100%	100%

Table 25. Focus of coaches' interactions during facilitating teacher professional learning

Focus of Interaction	Almond Valley	Cypress
Doing math together with discussion	38%	29%
How to use/coordinate instructional materials	23%	0%
Student thinking and learning	15%	29%
Instructional practices	15%	15%
Detailed planning for lesson	8%	7%
General discussion of students or how things are going at the school	0%	20%
	100%	100%

Table 26. Focus of coaches' interactions during observing and debriefing teachers' instruction

Focus of Interaction	Almond Valley	Cypress
Instructional practices	31%	30%
Superficial features of classroom instruction	20%	13%
Student thinking and learning	20%	23%
How to use or coordinate instructional materials	13%	3%
General discussion of students or how things are going at the school	11%	10%
Logistics of teacher learning	2%	3%
General discussion of how a lesson went	3%	18%
	100%	100%

Table 27. Focus of coaches' interactions during responding to individual teacher needs

Focus of Interaction	**Almond Valley**	**Cypress**
Instructional practices	31%	0%
How to use or coordinate instructional materials	32%	18%
Superficial features of classroom instruction	18%	0%
Student thinking and learning	6%	9%
General discussion of how a lesson went	6%	0%
Sharing materials	6%	10%
Logistics of teacher learning	0%	18%
General discussion of students or how things are going at the school	0%	45%
	100%	100%

Table 28. Focus of coaches' interactions during planning for school improvement

Focus of Interaction	**Almond Valley**	**Cypress**
Instructional practices	29%	0%
Logistics of teacher learning	29%	83%
Student thinking and learning	18%	0%
Superficial features of classroom instruction	14%	0%
General discussion of students or how things are going at the school	10%	17%
	100%	100%

Table 29. Focus of coaches' interactions during building district level capacity

Focus of Interaction	**Almond Valley**	**Cypress**
Mathematics curriculum development	80%	0%
Logistics of teacher learning	20%	0%
Non math-focused	0%	100%
	100%	100%