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Paula M. Jakopovic

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by

Paula M. Jakopovic

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Understanding What Makes for Productive Coaching Moves in Helping Teachers Attend to Mathematical Tasks of Teaching

Paula M. Jakopovic, Ph.D.

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Advisor: Ruth M. Heaton

Reforms in mathematics education call for teaching to move away from "traditional" approaches (Carpenter, Ansell, & Levi, 2001) that are focused around rote procedures and skills, and toward practice that engages students in cognitively demanding tasks, discourse, and productive struggle to develop conceptual and procedural understanding (NCTM, 2014). This type of teaching is complex, often requiring teachers to develop new content and pedagogical knowledge (Hill, et al., 2008). One professional development effort that attempts to address this need is the implementation of mathematics coaches in schools. Coaching efforts have met with mixed success to date (Campbell & Malkus, 2011; Coburn & Russell, 2008), therefore it is important to examine which aspects of their role can be most effective in advancing teacher practice.

In this qualitative study, I examined the coaching moves of six elementary coaches during lesson planning and debriefing. All participants were full time coaches in a large, urban school district in the Midwest. The focal question of this study is: How do mathematics coaches craft the conversations they have with teachers during planned three

part coaching cycles in the way that they do in order to promote teacher reflection and shifts in instructional practice? The data analyzed included transcripts from planning and debriefing sessions, field notes, pre- and post- observation interviews with coaches, and formal interviews at the end of the study with the coaches and a sample of teachers.

The analysis in this study suggests that coaching moves were more productive when they: 1) helped teachers attend to a range of mathematical tasks of teaching, 2) made connections between and among major teaching themes, 3) were worded specifically, and 4) included follow up moves. Understanding the ways coaches enact coaching moves productively is critical to providing training and support for mathematics coaches that lead to effective coaching programs (Ross, 1992). I also found that identifying the types of contextual factors present during coaching sessions, as well as the potential influence such factors may have had on the productivity of the coaching moves, was an important feature to better understand why some coaching was more productive than others.

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Someone much wiser than I suggested that it is not the end product, but the journey that matters. I hardly consider this paper to be “finished,” but I am proud of the insights I have made to this point. It is about polishing the rough edges away with time, feedback, and reflection. The process is the part that matters, and I am grateful for the tools I have gained through this journey that will aid in improving my future work.

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Chapter One

Statement of the Problem

"An excellent mathematics program requires effective teaching that engages students in meaningful learning through individual and collaborative experiences that promote their ability to make sense of mathematical ideas and reason mathematically"- Principles to Actions: Ensuring Mathematical Success for All (NCTM, 2014, p. 7).

Mathematics Educational Reform and the Demands on Teacher Knowledge and Practice

In recent decades, leaders in mathematics education have pushed for teachers to promote mathematics learning that encompasses a balance of procedural and conceptual understanding, in ways that incorporate high leverage tasks that are both engaging and cognitively demanding for students (Kilpatrick, Swafford, & Findell, 2001; Skemp, 1978). In doing so, teachers are expected to help encourage the development of students' identities as mathematical thinkers and doers (Aguirre, Mayfield-Ingram, & Martin, 2013), and to develop productive dispositions toward mathematics (Kilpatrick, Swafford, & Findell, 2001). In past international studies of mathematics education and achievement, programs in the United States were characterized as "…shallow, undemanding, and diffuse in content coverage" (Kilpatrick, Swafford, & Findell, 2001, p. 4). Such findings are at odds with this vision, and drive the most recent reform efforts in standards development, textbook and curriculum writing, and perhaps most critically, teacher professional development.

Over the past ten years, leaders in mathematics education, including the National Council of Teachers of Mathematics (NCTM), have made major strides in advocating for mathematics instruction at the elementary level that is more "intellectually honest" to the discipline (Bruner, The process of education, 1960). The development of the Common Core State Standards for Mathematics (CCSS-M) (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), as well as other comparable state mathematics standards, provide teachers with rigorous guidelines to address these content-focused ideas. Such reform based documents also include a focus on the importance of incorporating mathematical practices into instruction at all levels. Textbook publishers have focused recent curriculum design around these standards and practices, and many teachers are being required to teach in ways that are often very different from how they may have learned or previously taught mathematics.

Despite the changes occurring to standards and resources for teaching reform-based mathematics, little has changed in teacher practice. Carpenter, Ansell, and Levi (2001) describe traditional mathematics teaching as focusing on individual lessons, with skills from each lesson forming the foundation of knowledge needed to learn subsequent skills in later lessons. Typically, each lesson has a mathematical objective, and lessons move from objective to objective across a concept. Kilpatrick, Swafford, and Findell (2001) describe a continued pervasive use of “recitation” teaching models in mathematics classrooms across the United States. This model is one where teachers lead students through a demonstration of new material, use questions that require closed responses, followed by time for students to practice the day’s skill. This traditional model for teaching mathematics affords little opportunity for teachers to assess the depth of students’ mathematical understanding in ways that could inform their instructional decision making. Teaching models such as this are at odds with the teaching practices described by the quote at the start of this chapter, practices that are engaging and collaborative, and that help students see mathematics as a sense-making and connected discipline.

In their international study, Stigler and Hiebert (1999) found that mathematics teaching in the United States is most often teacher led, direct instruction of definitions and procedures, followed by student practice of the skill. The researchers stated that teachers paid little to no attention to students' mathematical thinking in mathematics lessons observed during their study. Similarly, Smith III (1996) explained that traditional teaching by "telling" continues to happen in classrooms because many teachers believe demonstration teaching is necessary for students to learn mathematics. When students learn mathematics in ways that are assumed to be hierarchical or disconnected, and when they do not understand certain skills along the way, they are unable to make connections or apply their knowledge to new problem situations. Reform based mathematics teaching seeks to address these deficits in traditional teaching practices by focusing on and fostering deep mathematical understanding in students.

Scott Nelson, Warfield, and Wood (2001) argued that students need to "…actively construct mathematical knowledge for themselves" (p. 6) to generate their own understanding, rather than passively receiving information from the teacher. Doing so requires a shift in teachers' conceptions of what it means to teach mathematics (Peterson, Carpenter, & Fennema, 1989), and a reconstruction of their knowledge for teaching mathematics (Schifter & Fosnot, 1993). In response to reform measures and the need to support teachers' learning of how to teach mathematics in these ways, researchers and subsequent educational publications have promoted the use of high leverage, research-based pedagogical practices (Ball, Thames, & Phelps, 2008; NCTM, 2014;

Smith & Stein, 2011; Stein, Smith, Henningsen, & Silver, 2009) in mathematics. In *Principles to actions: Ensuring mathematical success for all* (2014), NCTM advocated for designing lessons around focused mathematical goals that help students to move along learning progressions, and that keep student thinking and discourse as a central part of instruction. Such lessons create opportunities for teachers to help students make sense of mathematical concepts as building upon and connected to one another, rather than seeing math as an isolated series of skills.

Carpenter, Ansell, and Levi (2001) agreed with a need to conceptualize mathematical objectives and lesson design in ways that promote progress based on students' current understanding and strategy use. Mathematical goals are no longer tied to isolated lessons and skills, but help students to make connections among big ideas. This means that teachers must have not only a clear understanding of mathematical learning trajectories that student understanding progresses along, but also have ways to get at student understanding to carefully select and facilitate activities that promote growth. Mathematical problems and activities are chosen to promote reasoning and problem solving, and to help students make connections among representations in ways that help them develop procedural fluency based on deep conceptual understanding (NCTM, 2014; Skemp, 1978).

Teachers must adjust current knowledge and practices, and at times learn and incorporate new knowledge into their teaching practice to teach math in this way. Some of these pedagogical practices, such as attending to the cognitive demand of problems to make them accessible yet mathematically challenging for students, force teachers to think about their role in developing and enacting curricula in ways they previously have not

(NCTM, 2014; Stein, Smith, Henningsen, & Silver, 2009). Other practices, like incorporating student discourse and creating lessons centered on student thinking push teachers to shift toward a student centered practice where instruction was previously teacher-led (Chapin, O'Connor, & Anderson, 2013). Although such notions are promoted by leading researchers and mathematics educators at a national level (Ball, Thames, & Phelps, 2008; Carpenter, Fennema, & Franke, 1996; NCTM, 2014), helping teachers locally to envision and adopt such practices into their individual practice can prove a formidable task.

Reconceptualizing Teacher Knowledge: The Mathematical Tasks of Teaching

In order to design and implement well-crafted mathematical lessons, teachers must call upon specialized mathematical knowledge that is in some ways very different than the mathematics they learned as elementary students, or even in college preparatory classes (Hill, et al., 2008). Teachers must be able to anticipate the various strategies students may use to solve problems, and consider ways to monitor and scaffold their progress during instruction. They must be able to listen to and make sense of student explanations, often quickly during a lesson, and make in the moment decisions as to how to facilitate and guide discussion as it is unfolding. Even when these practices are not new for a teacher, such skills are often enacted differently in reform based teaching models than in more traditional mathematics classrooms (Ball & Forzani, 2011). Specialized content knowledge, as well as knowledge of mathematical content and how it connects to students and instruction (Ball, Thames, & Phelps, 2008), are necessary for teachers to conduct mathematics instruction in the ways advocated for by current research reforms (NCTM, 2014). Classroom teachers are often afforded little time to reflect upon and refine their current practices in ways that could help them learn to develop and strengthen these types of knowledge needed for teaching. Additional supports are often needed for this teacher learning around reform-based mathematics instruction to be supported in practice (Hill & Ball, 2004).

According to Ball, Thames, and Phelps (2008), teachers utilize specific types of knowledge to engage in a variety of tasks that pertain to the planning and implementation of mathematics instruction on an ongoing basis. These “mathematical tasks of teaching” require teachers to apply this knowledge in ways that are both specific and demanding in their daily practice, and include

- presenting mathematical ideas,
- responding to Students’ “why” questions,
- finding an example to make a specific mathematical point,
- recognizing what is involved in using a particular representation,
- linking representations to underlying ideas and other representations,
- connecting a topic being taught to topics from previous or future years,
- explaining mathematical goals and purposes to parents,
- appraising and adapting the mathematical content of textbooks,
- modifying tasks to be either easier or harder,
- evaluating the plausibility of students’ claims (often quickly),
- giving or evaluating mathematical explanations,
- choosing and developing useable definitions,
- using mathematical notation and language and critiquing its use,
- asking productive mathematical questions,
- selecting representations for particular purposes, and
- inspecting equivalences (Ball, Thames, & Phelps, 2008, p. 400).

Ball, Thames, and Phelps’ article itself did not give descriptions of individual tasks, however several related articles offer working definitions for some, but not all, of the teaching tasks. Selling, Garcia, and Ball (2016) and Kim (2016) provided definitions for eight of the tasks. The task regarding “Connecting a topic being taught to topics from prior and future years” relates to Ball, Thames, and Phelps’ description of “horizon mathematics" (2008). The tasks of "Appraising and adapting the mathematical content of textbooks" and "modifying tasks to be either easier or harder" relates to the literature on cognitive demand (Stein, Smith, Henningsen, & Silver, 2009) and *5 practices for orchestrating productive mathematical discussions* (Smith & Stein, 2011) around problem development. *Principles to actions: Enacting mathematical success for all* (NCTM, 2014) provided a detailed description of, "Asking productive mathematical questions." The remaining tasks, "Explaining mathematical goals and purposes to parents," "Choosing and developing useable definitions," and "Using mathematical notation and language and critiquing its use" are fairly self-descriptive in nature. A complete list of the mathematical teaching tasks and their definitions is available in Appendix A.

The recent literature on mathematics teaching and learning suggests a list of reform-oriented teaching practices necessary to develop students' mathematical knowledge: establishing clear mathematical goals, implementing rich tasks that promote problem solving, fostering connections between mathematical representations, promoting productive struggle by posing questions and fostering student discourse, and helping students develop procedures based on conceptual understandings (NCTM, 2014). These teaching practices are closely aligned with the mathematical tasks of teaching that are centered around developing mathematical goals, choosing and connecting representations, asking purposeful questions, evaluating student explanations and claims, and considering ways to present mathematical ideas meaningfully (Ball, Thames, & Phelps, 2008). Helping teachers to develop not only an awareness of these mathematical tasks of teaching, but also to cultivate a deeper understanding of how they can implement these tasks into their practice effectively, is critical to strengthening these facets of planning and teaching reform-oriented mathematics. When teachers do not have strong mathematical knowledge for teaching, they are less able to engage in these tasks of teaching in ways that promote meaningful and effective mathematics instruction (Hill, et al., 2008). In order for teachers to successfully engage students in reform based mathematical learning, they must be afforded opportunities to learn how to consider mathematics planning, teaching, and learning in reform minded ways.

Tasks Focused on Student Thinking

Some of these mathematical tasks of teaching were more recently developed and came about as a result of the shift toward reform based mathematics teaching around attending to student thinking and reasoning in mathematics. For example, anticipating or "evaluating the plausibility of students' claims" or "giving or evaluating mathematical explanations" (Ball, Thames, & Phelps, 2008) requires there to be opportunities during the lesson for students to share ideas and claims. This indicates a shift in teaching practice away from teacher led, modeled instruction of skills and toward mathematical knowledge being generated by students' mathematical reasoning (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014). This requires a shift in knowledge for planning and teaching mathematics that differs from that required for traditional mathematics teaching by adding an emphasis of the role that student knowledge and strategy use can play in shaping the lesson. Incorporating mathematical discourse and using evidence of student thinking to inform and adjust instruction are key reform oriented teaching practices that teachers must develop facility with to make such shifts in practice (NCTM, 2014; Smith & Stein, 2011).

Incorporating these types of mathematical tasks of teaching into planning and instruction can be both new and, at times, challenging for teachers to do successfully. Smith and Stein (2011) described how allowing students to share their mathematical reasoning and explanations could at times devolve into a "show and tell" of different strategies that did not facilitate mathematical connection-making to occur. Teachers also found it risky to have students leading the conversation around the mathematics because at times student explanations were unclear or contained errors and misconceptions, making it challenging to move student thinking forward productively (Chapin, O'Connor, & Anderson, 2013). This can make it difficult for teachers to adopt such practices into their teaching because it requires a different set of knowledge than traditional planning and teaching. To incorporate these mathematical tasks of teaching, teachers must learn to anticipate and plan for student responses before the lesson, and to address anticipated and unanticipated student thinking during the lesson as well. This requires a different type of planning and preparation than traditional mathematics instruction. Teachers must develop a reform based mindset around not only teaching mathematics, but also planning for mathematics instruction, that is focused around facilitating student discourse and helping students "grapple with mathematical ideas and relationships" (Hiebert & Grouws, 2007; NCTM, 2014, p. 10).

Tasks Focused on Mathematical Goals

Another mathematical task of teaching that requires a shift in knowledge for planning and teaching mathematics is that of "linking representations to underlying ideas and other representations" (Ball, Thames, & Phelps, 2008, p. 400), which closely relates to NCTM's (2014) reform based teaching practice of using and connecting mathematical representations. In traditional mathematics teaching, lessons have objectives that typically focus on the skill of the day, rather than on helping students to make connections between and among mathematical concepts (Carpenter, Ansell, & Levi, 2001). In reform based mathematics teaching, students develop a variety of strategies, often moving from concrete representations toward efficient strategy use along a learning progression (Bruner, 1966; Clements & Sarama, 2004). In order to help students increase the sophistication of their understanding and strategy use, teachers must learn to help students see the connections between particular representations. This requires teacher to take on the role of learner (Feiman-Nemser, 2001) and to consider the connections between different strategies and representations themselves. Teachers must also develop mathematical goals that include helping students to understand not only day to day content, but the overarching mathematical ideas as well (NCTM, 2014). Such goals are broader than traditional lesson objectives, and require teachers to have knowledge of the mathematical connections, student understanding, and ways to design lessons to incorporate this mathematical task of teaching in their practice.

Tasks Focused on Mathematical Problem Design

The mathematical task of teaching around "presenting mathematical ideas" (Ball, Thames, & Phelps, 2008) is perhaps one of the most common tasks of teaching, as it is at the heart of mathematical lesson planning. In traditional teacher-led mathematics teaching, the teacher might determine which problem from the textbook they would use to model a mathematical idea or process for students. After demonstrating the target skill, the teacher would typically provide similar problems for students to practice in order to gain proficiency in the skill. In a reform based teaching model, presenting mathematical ideas would require the teacher to consider the cognitive demand and design of the problem to ensure that anticipated and desired student strategies will come out during the lesson (Stein, Smith, Henningsen, & Silver, 2009). The teacher would need to ensure that the problem design and presentation aligned with their broader mathematical goals for student learning, and that the problem engages students in problem solving and reasoning in ways that allow for multiple entry points and strategies (NCTM, 2014; Stein, Smith, Henningsen, & Silver, 2009).

Carpenter, Ansell, and Levi (2001) described the planning that occurs around this mathematical task of teaching as the design of problems that are "…carefully selected to facilitate conceptual growth of students by building on what they generate" (p. 29). To facilitate discussion, planning for the sorts of questions that would get at these strategies and explanations rather than focusing on correctness of answers, would also look different in reform-based versus traditional mathematics teaching. Teachers must learn to pose carefully crafted, open ended questions that help to move students' understanding of mathematical ideas forward as they monitor discussions during the lesson (NCTM, 2014; Smith & Stein, 2011). Teachers need to ask a range of question types, including those that promote student explanations and justification, as well as ones that help make mathematical structures and connections visible to students (Boaler & Brodie, 2004). They must also learn how to, often in the moment, offer good follow up questions to student responses to move mathematical conversation and thinking forward productively (Franke, et al., 2009).

These questioning practices stand in stark contrast to the goal of questions in traditional mathematics classrooms, where instruction tends to focus on ensuring students understand definitions, processes, and formulas. The types of questioning patterns that emerge when this is the goal of teacher questioning typically is an “Initiate-Response-Evaluate” (I-R-E) approach (Mehan, 1979) or a “funneling” pattern (Wood, 1998). In I-R-E, the teacher asks a question, often with a targeted response in mind, then evaluates the correctness of the student response before moving on to a different question. This approach allows little insight into students’ mathematical thinking and reasoning, and offers limited opportunities to help students make connections between mathematical ideas. Although “funneling” uses a series of follow up questions to elicit further ideas from students, the teacher uses these questions to steer the direction of the conversation toward a targeted idea, rather than using student reasoning to build connections. Not only must teachers learn how to pose different types of questions, they must also develop different patterns of questioning to use student thinking to make connections and move mathematical understanding forward (NCTM, 2014).

These examples of how mathematical tasks of teaching interact with one another, as well as how they look different in traditional versus reform-based teaching, demonstrate the complexity of the knowledge that teachers must develop to teach mathematics in this way. It can be challenging for teachers to develop awareness and facility of the mathematical tasks of teaching that help to increases their awareness and use of reform based teaching practices on their own, without professional development to strengthen their pedagogical and content knowledge. Teachers need support systems that can help them translate their knowledge of the mathematics, the curriculum, and their students into sustainable, reform-based teaching practices. The National Mathematics Advisory Panel (2008) found a lack of rigorous, high quality studies to link professional development in mathematics teaching to student achievement gains. Finding methods to offer such supports to teachers, in ways that are both persistent and pervasive to affect ongoing efforts at effectively implementing such practices, is a major challenge facing all of the major stakeholders in mathematics education.

Providing Supports and Opportunities for Teachers to Develop Such Knowledge

The increased demand of teaching mathematics at the elementary level has created a need for new and better ways to provide professional development for in-service teachers. The challenge is to develop deeper mathematical knowledge in teachers, and help them cultivate the tools and techniques to design and implement research-oriented instruction that supports all learners and is responsive to the mathematical tasks of teaching. Ensuring support is critical to helping teachers consider ways of teaching mathematics that involve a comprehensive approach to fostering children’s capacities as mathematical learners (Kilpatrick, Swafford, & Findell, 2001). The incorporation of reform-based mathematical standards and curricula have led to an increased need for newer and more effective forms of teacher professional development in recent years. The sort of teaching suggested by these reforms, including encouraging student discourse and productive struggle (Smith & Stein, 2011; Stein, Smith, Henningsen, & Silver, 2009), as well as adapting questioning patterns to foster conversation that develops mathematical ideas from the thinking of students (Herbel-Eisenmann & Breyfogle, 2005), is quite different from the instruction and learning experiences of many classroom teachers, however, and creating a shift in practice has proven challenging. In-service professional development has traditionally been brief, not maintained over time, and lacking in depth of content (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Hawley &

Valli, 1999), and research has pointed to effective professional development as both being sustained and substantive, as well as embedded directly within teachers' practices (Feiman-Nemser, 2001) for teacher learning to occur.

In response to this research on professional development and the lack of impact that many current teacher learning opportunities have had on classroom practice, possible reforms to teacher professional development have come under serious consideration. The need for changes in traditional professional development models is not a new idea. Determining what sorts of new approaches to professional development offer the potential to be most effective in supporting teacher learning of reform-based mathematics teaching is a topic under much discussion in the recent literature on teacher professional development. The Conference Board of Mathematical Sciences (2012) made a series of recommendations for both leaders in school districts and mathematics educators at the university level on how to best train and support both pre-service and in-service teachers in developing the necessary understandings of content and pedagogy. With regard to practicing teachers of mathematics, the board recommended that, "Throughout their careers, teachers need opportunities for continued professional growth in their mathematical knowledge," (p. 18).

The report described a variety of potential avenues for teacher professional development. Three such approaches that have gained popularity in recent years are 1) the implementation of professional learning communities within schools, 2) offering extensive professional development workshops focused on mathematics teaching and learning, and 3) the development of instructional coaches to act as on-site professional developers for schools and districts. In the following sections, I examine the benefits and potential limitations of these alternative forms of professional development as potential supports for elementary mathematics teachers.

Professional Learning Communities

Developing a deeper understanding of mathematics teaching requires teachers to communicate openly, ask questions, and create a sustainable reform-oriented mindset around teaching and learning. Teachers are able to do this through what Himley called "deep talks" (1991) with other teachers and professionals who help them reflect thoroughly and intentionally on the incorporation of new or refinement of current practices. Assuming a sense of "shared responsibility" for student learning involves developing a community of practice, where teachers collaborate, share knowledge and ideas, and develop their practice together rather than in isolation (Little, 1999; Wenger, 1998). When teachers can break down barriers to isolation and develop communities of practice that are focused and supportive, shifts in teacher learning and teaching practice can occur over time (Hadar & Brody, 2010).

One type of collaborative effort that has been enacted in a variety of ways across different schools and districts is the development of professional learning communities, or PLCs (DuFour & Eaker, 1998). This model of professional learning provides teachers an avenue to have ongoing, sustainable conversations and reflection around their practice throughout the school year (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). The shifts created by this collaborative reflection can increase teacher efficacy (Bruce, Esmonde, Ross, Dookie, & Beatty, 2010) and foster the creation of "local knowledge" among participants (Cochran-Smith & Lytle, 1993). Such evidence suggests that it is critical for professional developers to build in supports for teachers that are practice-embedded and differentiated to meet the needs of both individual teachers and the collective group at the same time. Professional development that occurs "in practice" provides opportunities where teachers can connect new and existing content and pedagogical knowledge with their teaching practice (Buysse, Sparkman, & Wesley, 2003).

Some research studying communities of practice indicates that not all teacher groups focus their energies on continued learning and improving their practice (McLaughlin & Talbert, 2001). Little (2002) described three goals of teacher communities of practice that influence their productivity: helping teachers develop representations of practice that are accurate and transparent, developing an orientation toward enhancing practice, and creating norms for group interactions that maintain focus and progress through group discussion. In order for such a practice to be successful in helping teachers learn to navigate planning and teaching while being responsive to the mathematical tasks of teaching, teachers must first have knowledge of these tasks, their potential value, and know what it means to incorporate them effectively. In such situations, having a "knowledgeable other" to focus reflective conversations and move teacher thinking forward could prove advantageous (Bean, Draper, Hall, Vandermolen, & Zigmond, 2010). When a knowledgeable individual is not available to act as a resource and provide focus for conversations around teaching reform-oriented mathematics, there are limitations to this type of professional development opportunity. Professional learning communities do not always provide adequate support to help teachers improve their content and pedagogical knowledge in mathematics in the ways research and reform demands (Stoll, Bolam, McMahon, Wallace, & Thomas, 2006).

Professional Development Workshops and Courses

Another potential opportunity for teachers to increase their knowledge and capacity for planning around reform-based mathematics instruction and mathematical tasks of teaching is within professional development workshops and programs. Often these workshops and courses are offered through mathematics education programs in collaboration with universities and other educational and research based organizations. The goal is to help teachers develop deeper mathematical and pedagogical understanding, in ways that attend to a range of mathematical tasks of teaching. One such program, Cognitively Guided Instruction (CGI), sought to help teachers understand research based knowledge around how children develop an understanding of mathematics. The program attempted to do so by helping teacher learners to formalize and organize this specialized knowledge in ways that helped them plan their instruction around analysis of students' mathematical thinking (Carpenter, Fennema, & Franke, 1996).

CGI helped teachers to understand the progression of student learning in both complexity and levels of abstraction, typical strategies and errors, and how to help students develop a conceptual understanding of mathematical concepts using this knowledge. Analyzing student strategies and thinking, as well as helping teachers consider what is involved in various mathematical representations with regard to complexity and abstraction, are aligned with several mathematical tasks of teaching: 1) evaluating students' mathematical claims, 2) recognizing what is involved in using a particular representation, and 3) linking representations to underlying ideas and other representations. These teaching tasks are also connected to the mathematical teaching practices of eliciting and using evidence of student thinking and using and connecting mathematical representations that are promoted by *Principles to actions: ensuring mathematical success for all* (NCTM, 2014). These examples illustrate ways in which the goals of programs like CGI and the vision of reform-based mathematics teaching that is based around mathematical tasks of teaching and reform based teaching practices are closely aligned (Ball, Thames, & Phelps, 2008; NCTM, 2014).

NCTM (2014) described the importance of reform based teaching practice as centering around situating mathematical teaching goals and tasks that are situated within learning progressions. In a report on their findings of CGI's work with classroom teachers to develop understanding of the progression of student thinking and strategy use over time, Carpenter, Fennema, and Franke (1996) explained that teachers either tended to see their learning in the program as generative or as acquiring a fixed body of knowledge. Those who saw their knowledge of student thinking as generative used this as a basis to develop new and deeper understandings of mathematical thinking over time, as a practice that could be continued and refined beyond the scope of the study. Unlike their peers, these teachers saw themselves as the creators of knowledge, rather than receiving this knowledge from expert others (Carpenter, et al., 2004).

This generative self-image of teaching aligns with reform-based teaching practices promote problem solving and reasoning, and uses purposeful questions to generate mathematical discourse where students develop connections and strategies around big mathematical ideas (NCTM, 2014; Smith & Stein, 2011). Such findings suggest that this work has the potential to help teachers develop their awareness of and responsiveness to broader ranges of mathematical tasks of teaching in their practice, as many of these teaching tasks are designed to engage students in making connections between mathematical representations and ideas. Tasks such as “presenting mathematical ideas” and “linking representations to underlying ideas and other representations” (Ball, Thames, & Phelps, 2008) take on new meaning when teachers adopt a generative stance about the development of mathematical knowledge that centers around student thinking (Smith & Stein, 2011).

Another program that looked to help teachers develop their awareness and use of mathematical tasks of teaching was Project IMPACT, a program was designed to have teachers schoolwide complete an intensive summer workshop, followed up through the school year by collaborating with a mathematics specialist (Campbell, 1996). Topics that teachers were trained on in the workshops included higher level mathematical content, teaching mathematics conceptually, sharing research and strategies on how children develop this understanding, and ways to support diverse learners (Skemp, 1978). Much like CGI, the professional developers for Project IMPACT engaged teachers in the types of problem solving environments they hoped would translate to their teaching practice, as well as pressed teachers to focus on analyzing students’ mathematical thinking and understanding, goals that are aligned with reform-based teaching practices (NCTM, 2014). Their study found that only about 40% of teachers in the program made “significant changes in their instruction” (p. 467) and the reform based mathematics instruction the program advocated for occurred in about 30% of participants’ classrooms by the end of the study. Such findings indicate that providing coursework alone is not always enough to help improve teacher practice around noticing and engaging with reform based instructional practices or mathematical tasks of teaching.

Another limitation of offering external workshops and courses as a form of professional development is that offering such courses and workshops is not always feasible in all schools and districts. Programs may not be available locally, or funding for such extensive professional development may not be possible. Since such workshops often occur outside of teacher contract time, many school districts may find it challenging to recruit and enroll all teachers to ensure everyone has equal access to this sort of conceptual and pedagogical learning. Although it may not be possible to fund or encourage participation of all staff in such programs in all schools and districts, one positive implication that came out of the Project IMPACT study was the potential impact of having a “mathematics specialist” on site to help teachers to implement new knowledge into practice. Not all teachers have the opportunity or desire to attend workshops and trainings that occur outside of their professional day. One potential alternative to off-site professional development is to offer embedded, on site support from an individual with strong knowledge of the mathematical content and pedagogy external courses and programs develop, but available in the classroom and during teacher’s ongoing practice. Teachers who might not otherwise enroll in extracurricular workshops and courses would have access to this on site expertise in a sustainable way through the implementation of building based mathematics coaches.

Instructional Coaching

It is difficult for professional developers to anticipate and address the complex issues that arise when planning for and enacting lessons in the classroom with regard to reform-based instruction and mathematical tasks of teaching when learning occurs in external workshops (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009).

Likewise, teachers must juggle a variety of contextual factors that make it difficult to interpret newly learned theories and pedagogical ideas into effective classroom practice (Smith , 2012). Allowing time for teachers to discuss strategies *as* they try new things in their classrooms gives them an opportunity to directly translate suggestions and conversations among colleagues into the practice in a timely manner. Researchers and leaders in the field of math education have suggested several alternatives (Cochran-Smith & Lytle, 1999; Carpenter, Fennema, & Franke, 1996; DuFour & Eaker, 1998), but this section presented potential limitations to each of these possibilities.

Although PLCs may offer one potential way to support teacher growth, at times the members of such groups may not have adequate knowledge or understanding of the practices around reform-oriented mathematics instructional design that need to be considered in order to move practice forward (McLaughlin & Talbert, 2001). Even though professional workshops and mathematics professional development programs offer another alternative (Campbell & White, 1997; Carpenter, Fennema, & Franke, 1996), it is it often challenging to fund and persuade teachers to enroll in such programs. At times, such programs are not even available to teachers within some schools and districts. Instructional coaching offers a potential solution to help teachers situate professional learning within their practice. Coaches can offer supports real-time from a knowledgeable specialist, without having to address some of the other roadblocks that these alternate forms of professional development may create.

Instructional Coaches as a Professional Development Alternative for Teachers

Despite knowing that needed change to professional development models is not a new idea, determining what approaches have the potential to be most effective has been a topic of much discussion in recent years. Not only is collaboration key, so is developing an understanding of the rationale behind changes and refinements in practice. Additionally, McLaughlin (1993) described a “substantial diversity in teachers’ goals for students (p. 83),” explaining that variations occurred because teachers had different interpretations of what it means to teach and how the needs of their students influence this. Coaches can help develop collaborative communities within schools and assist teachers as they develop understanding of new conceptual and pedagogical ideas with fidelity (Campbell, Ellington, Haver, & Inge, 2013). A coaching model of professional development allows teachers to be active participants in constructing meaning of these ideas within their practice.

Situating a knowledgeable individual in schools can help to foster collaboration, as well as help schools develop a shared vision of what it looks like to teach mathematics. Coaches are able to collaborate with entire staffs, small groups of teachers, or with individuals in a given school (Campbell, Ellington, Haver, & Inge, 2013; Neufeld & Roper, 2003). Such flexibility allows teachers access to a colleague who can help them plan and reflect deeply, acting as an access point to content knowledge and resources to help teachers consider the complex issues of teaching. It can also afford opportunities for teachers and coaches to set very personalized goals and pacing, rather than the “one-size fits all” approach that traditional professional development typically does (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009).

Coaches can act as brokers between the information being presented in formal professional development related to educational reforms and how teachers interpret and implement (or ignore) such ideas in their pedagogical practice. As members of the building group and culture, coaches are positioned so that they can develop positive relationships with teachers. In doing so, coaches can act as team coordinators in professional learning communities (Costa & Garmston, 2002), helping teacher groups to focus and work toward common objectives in a positive environment. Instructional coaching offers a potentially powerful alternative then, to traditional professional development measures. Coaches are positioned to help teachers understand reform-based teaching initiatives, and can do so in ways that meet teachers where they are along a "personal professional trajectory" toward awareness and refinements in practice (Brody & Hadar, 2015). Mathematics coaches offer a type of differentiated professional development for classroom teachers, one that can be both sustainable over time, and actively occurring in and around instruction.

Developing a deeper understanding of some of the specific components of the role and the supports coaches provide for teachers is critical then in determining how coaching can be enacted in ways that maximize the potential progress and growth in teacher learning over time. Better understanding this work can inform those who develop and provide support to mathematics coaches to ensure these coaches will understand how to enact their role in ways that help teachers deeply reflect upon and refine their teaching practices.

The Current Literature on Coaching

Darling Hammond et al. (2009) described a "new kind of teaching" (p. 7) as necessary to promote student learning and success. In considering how to help teachers enact this new sort of teaching, a meta-analysis conducted by Blank and Atlas (2009) suggested that professional development that focused on the content and pedagogical moves needed to teach mathematics effectively had a strong correlation to improved student learning. To help foster such shifts in teaching practice, they suggested professional development programs that were ongoing, collaborative, focused deeply on content, and embedded in teaching practice. These types of programs allow teachers time to try out new strategies and ideas in their classrooms with the support of a knowledgeable support person. It also allows them to engage in discussion and reflection around mathematical tasks of teaching before, during, and after the lesson. Studies suggest the need to view contemporary professional development for teachers as something that is complex and that should be situated in the context of teaching itself (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). Determining how these new types of professional development options can be developed to support teacher learning about and implementation of research-based practice has become a current area of focus in educational research (Campbell & Malkus, 2011; Campbell & White, 1997).

In order to understand how instructional coaching can act as a more effective form of professional development for teachers, it is important to examine the current research on coaching that both support and raise questions about coaching as an alternative. Joyce and Showers (1995) found that teachers can transfer new knowledge to classroom practice by participating in peer coaching and collaborative planning. Mesler-Parise and Spillane (2010) noted that formal professional development in conjunction with on-site opportunities for practice in context were strong predictors of change in teaching practice, especially when the on-site opportunities included collaborative discussion. Likewise, Putnam and Borko (2000) suggested that professional development should include intensive workshops that were “intertwined with ongoing practice” (p. 6) and positioned professional developers in teachers’ classrooms to collaborate with teachers. Instructional coaches can help schools provide a blend of formal on-site training that can promote growth in teachers’ knowledge, refine their ability to reflect on practice and in practice, and increase their use of highly effective instructional practices.

In their analysis of the research on instructional coaching, Kretlow and Bartholomew (2010) found that when professional development on effective instructional strategies was followed up with the support of a coach, teachers more successfully integrated the ideas into their practice. Their findings also described the importance of coaches providing observations of teacher instruction, modeling strategies, and offering ongoing feedback to help teachers improve over time. Such results indicate that coaches have the potential to provide the type of embedded, ongoing support for teachers that could promote the shifts in teaching practice described by the research (Campbell & Malkus, 2011; NCTM, 2014). Coaches can help teachers learn to attend to and plan around mathematical tasks of teaching in intentional, reform-oriented ways. It is important, then, to fully understand the development and enactment of the coaching role to inform the current body of literature in supporting effective coaching practice in schools.

The Evolution of the Role of Mathematics Coach

Even before the formalized role of mathematics coach was developed, literature existed on the concept of “peer coaching,” where teachers would observe and provide feedback on one another’s instruction in an effort to improve practice (Joyce & Showers, 1982). Other research has emphasized the importance of the coach as a “knowledgeable colleague” (Campbell, Ellington, Haver, & Inge, 2013). In some instances, this resident expert came from the university level, such as in Olson and Barrett's (2004) study that examined various coaching methods utilized to promote teacher learning. Most recently in the literature, however, the coaching role has developed into part and full-time positions held by former classroom teachers after initial training has been provided (Bruce & Ross, 2008; Herrelko, 2011; Kretlow & Bartholomew, 2010). Despite the existence of coaching for over two decades in the professional literature, the actual design and implementation of the mathematics coaching role continues to vary across the existing research.

Instructional coaching has been defined in a variety of ways across the literature, and there are many different models for enacting coaching (Murray, Ma, & Mazur, 2008). Coaching roles with various levels of coaching responsibility have been developed, including district coaches, multi-site coaches, individual building coaches, and teachers with release time from the classroom to act as a coach (Mudzimiri, Burroughs, Luedbeck, Sutton, & Yopp, 2014). Coaches can be viewed as educators with equal status as their classroom teachers, or as experts or mentors who have more of a hierarchical nature in their relationship with teachers (Murray, Ma, & Mazur, 2008). These different definitions of the coach-teacher relationship, as well as different visions of coaching from administrators, can lead to a divergence in coaching roles as enacted in various settings.

Additionally, within these varied types of coaching roles, individual coaches collaborate with teachers in a range of ways, including assessing teachers' needs, modeling strategies in the classroom, providing feedback, and sharing expertise. Coaches engage in dialogue and probe classroom teachers' instructional decision-making to help them plan and reflect on instruction, and help to build common ground between classroom practice and district initiatives and policy (Huguet, Marsh, & Farrell, 2014; Killion, 2008). Coaches can help teachers to visualize what new practices and initiatives can look like when successfully implemented in classrooms, and can provide rationale and understanding for teachers as to why such initiatives can be useful. Content based coaches, such as mathematics coaches, have the potential to help teachers develop the mathematical and pedagogical knowledge needed to implement reform-based mathematics teaching into their practice, in ways that are responsive to the content, curriculum, and the knowledge needs of their students. Ball, et al. cautioned, “It is likely, however, that if the use of elementary math specialists is to have a positive effect, it will be because the training of specialists develops in a more focused way the mathematical knowledge for teaching shown to have effects on student achievement” (2008, p. 5-56).

Sutton, Burroughs, and Yopp (2011) described the definition of the coach as thus, “A mathematics coach is an on-site professional developer who enhances teacher quality through collaboration focusing on research-based, reform-based, and standards-based instructional strategies and mathematics content that includes the why, what, and how of teaching mathematics” (p. 13). This definition included a description of measurable practices that coaches should be engaged in, namely, to promote effective, research-based instructional practices that help teachers incorporate a range of mathematical teaching tasks into their planning. It is within this working definition of “mathematics coach” that the practice of coaches within the context of this study is broadly defined. Although a coach can support teachers in many different ways, it is important to understand those roles that can best support the reflective planning conversations between coaches and teachers around mathematical tasks of teaching. Recognizing the roles that coaches enact to foster these substantive conversations and the types of things coaches do to "enhance teacher quality," then, are critical to understanding what it means to coach teachers effectively.

The Roles of an Elementary Mathematics Coach: Theory and Practice

In practice, the roles and responsibilities of mathematics coaches can vary widely from site to site (Killion, 2008; Sutton, Burroughs, & Yopp, 2011), making the actual job description of a "mathematics coach" difficult to clearly define at times. In Table 1, Killion (2008) described ten roles that an instructional coach can take on in their work with teachers.

Table 1

Ten Roles of the Instructional Coach

Coaching Role	Purpose
Resource Provider	Gathers materials for teachers to help improve instruction
Data Coach	Works with individual and teams of teachers to discuss student data to inform instructional decisions
Curriculum Specialist	Helps teachers foster understanding of curriculum and materials to ensure use with fidelity
Instructional Specialist	Helps teachers with pedagogical and instructional decision making to differentiate instruction
Mentor	Provide support for new teachers to build instructional capacity
Classroom Supporter	Works in classrooms with teachers to observe, model, and co-teach lessons; as well as to conference prior to and after lessons to help teachers plan and reflect to improve instruction
Learning Facilitator	Develops and provides grade level and school-wide professional development
School Leader	Works with school leadership team to implement and monitor initiatives and to monitor instructional practices
Change Catalyst	Provides teachers with opportunities to consider alternatives to their current instructional practices
Learner	Seeks out ways to improve own knowledge and skill set

Note. From "Coaching roles, responsibilities, and reach," by J. Killion, 2008. In Corwin Press (Eds.), *Mentoring, coaching, and collaboration* (pp. 15-34).

In looking at roles that promote reflective conversations and deepen teachers' knowledge and understanding of how to effectively engage in planning that is centered around mathematical tasks of teaching, perhaps the roles worth examining more closely are those of classroom supporter and a catalyst for change. These two roles embody the sort of professional development that the research indicates is needed: a way for teachers to implement and reflect on instructional ideas in the context of their classroom practice. When teachers can reflect on mathematical tasks of teaching in real time, and are supported by a coach in doing so, opportunities are afforded to adjust thinking and instructional practices so that teachers can successfully incorporate reform based teaching practices in their planning. As such, these instructional coaching roles hold the most potential to push teachers to analyze their practice in ways that can positively influence student learning over time (L'Allier, Elish-Piper, & Bean, 2010; Saphier & West, 2009). Despite the clear description of these roles, and indications that supporting teachers in the process of planning and enacting lessons is a critical part of coaching, the reality of how these roles are enacted varies from coach to coach and from site to site in practice.

The lack of coherence in the literature describing what a coach *should do* has been shown to lead to differences in the enactment of what the coach actually *does* across the research. Coburn and Russell (2008) found that the way district initiatives involving coaching were designed makes a difference in the ways that coaching is configured in practice. These decisions impact the frequency and depth with which coaches interact with classroom teachers, as well as the depth of mathematical content discussed during reflective coaching conversations. Less frequent coaching led to weaker ties between teachers and coaches in the social networks of schools, which can be problematic because

"…it facilitates problem solving and the transfer of tacit, complex, or fine-grained information" (p. 215). Without such ties, the trust and rapport needed to deeply discuss the mathematics at the heart of planning often did not occur.

Bean et al. (2010) similarly found that the frequency with which coaches and teachers collaborate together related directly to both the perception of the teachers about the value in working with an instructional coach as well as gains in student proficiency. A lack of clear expectations, not only for coaches and their administrators, but also the teachers with whom they intend to work, adds to variance in the enactment of coaching roles as well. In their interviews with principals, coaches, and classroom teachers, Mraz, Algozzine, and Watson (2008) found that individuals held varying perceptions of the role of the coach, stating "…the perplexity that teachers expressed over what the literacy coach did or did not do in their school was consistent throughout the study" (p. 152). Such mixed messages about the role of the coach can result in a lack of cohesiveness of coaching programs in schools and districts (Fullan & Knight, 2011). Clearly defining what coaches do matters to all stakeholders so that a common vision is developed as to what the process will look like for all involved. Advocating for coaching roles that are focused directly on supporting the classroom practice of the teacher perhaps hold the most potential to positively influence mathematics instruction over time.

The Knowledge Needed for Instructional Coaching

In order for instructional coaching to be an effective professional development alternative for teachers, the training and knowledge of the coach must be thoroughly understood. Without adequate content and pedagogical knowledge, coaches are unable to support teachers in attending to mathematical tasks of teaching in ways that support reform-based teaching practices. For coaches to help classroom teachers improve their practice, coaches must have specialized knowledge that goes beyond that of a classroom teacher. Chval et al. (2010) described the transition from classroom teacher to that of a mathematics coach as one that required development of a new identity and acquisition of a broader set of professional skills. Coaches must understand the mathematical tasks of teaching, as well as anticipate which ones may be unfamiliar or challenging for classroom teachers to consider as they shift toward reform-based mathematics teaching. If the goal of coaching is to create fundamental shifts in how teachers go about planning and teaching, the role of the coach must help teachers shift the ways in which they think about this planning for *all lessons*. A particular challenge for coaches is how to help teachers learn to incorporate a range of mathematical tasks of teaching into their practice in ways that permeate practice beyond the scope of a single coached lesson and transform their teaching toward reform-oriented practice.

As well as possessing strong mathematical and pedagogical content knowledge, coaches must exhibit strong interpersonal and leadership skills, understand how to leverage available resources, and develop an understanding of how to work productively with adult learners (Campbell, Ellington, Haver, & Inge, 2013; Sutton, Burroughs, & Yopp, 2011). Neufeld and Roper (2003) described the essential components of successful coaching as having clearly defined coaching roles, ensuring coaches have substantial professional training, and developing a common vision among all stakeholders. The ways in which coaches receive such knowledge and professional development are often left up to individual schools and districts, resulting in fluctuations in the training and enactment of coaching in different settings. Even when coaches receive theoretical training in these areas, much like classroom teachers, they are often left to negotiate what it means to do this in practice on their own.

There is a unique subset of skills that coaches must develop to foster the types of "deep" conversations (Himley, 1991) with teachers that promote mathematical connection-making and analysis of mathematical tasks of teaching in their practice. In order for coaches to act as effective classroom supporters and change catalysts, they must develop a number of skills and learn how and when to use them in order to move their practice with teachers forward productively. According to Campbell et al. (2013), coaches must have good questioning techniques to help teachers reflect on thought provoking ideas and help them develop a deeper understanding of both the mathematics they teach and how student learn these concepts. Coaches help teachers to consider questions beyond just *how* they plan to teach the lesson, but also push them to think about the *what*, *why*¸ and *who* are involved in developing mathematically sound lessons (Campbell, Ellington, Haver, & Inge, 2013).

Coaches also help teachers to set goals, gather data and information for teachers, offer suggestions and ideas, and press them to consider and make choices related to lesson planning (West & Cameron, 2013). Campbell and Malkus (2014) described the core components of coaching in their studies as a focus on content, active learning, coherence, duration, and collective participation. As coaches craft conversations about teaching around the mathematical tasks of teaching related to particular concepts, they must find ways to do so that both promote shifts toward reform-based instruction while still being responsive to the goals of the classroom teacher (Ippolito, 2010). This repertoire of coaching "moves"- asking questions, helping teachers set goals, gathering and analyzing data, offering ideas and suggestions, and pressing teachers to make decisions in their planning based on these discussions- are central to helping teachers productively consider ways to center their planning and instruction around mathematical tasks of teaching.

Despite having a working body of knowledge that suggests what good coaches should know and be able to do, there is still much to be learned about what it looks like for coaches to negotiate this in practice. Much like teachers engaging a range of student learners, coaches must learn how to collaborate with teachers who are at various places in their awareness and use of mathematical tasks of teaching in their current practice. The goal of the coach is to help teachers construct their own knowledge and learning around teaching mathematics, much in the way that reform-based mathematics teachers attempt to do with students who are learning mathematics. In the current literature, there is little empirical evidence to offer coaches, and those who train them, examples of what it looks like when coaches are able to move teachers towards considering and working on mathematical tasks of teaching productively. Much of the research presents findings on the broad impacts of coaching initiatives, without sharing specifics about how coaches go about engaging teachers in reflecting on these ideas, and whether or not the work of the coach can overcome contextual factors that may act as potential barriers in their coaching practice.

Unpacking this role of the coach that centers around helping teachers plan in ways that are responsive to mathematical tasks of teaching is critical to better recognizing what it is that mathematics coaches do that moves teacher thinking forward. Understanding the potential contextual factors that can influence this coaching practice, beyond simply the knowledge and preparation of the coach, is a topic where research is still needed. Therefore, my proposed study attempts to answer the question: How do mathematics coaches craft the conversations they have with teachers during planned three part coaching cycles in the way that they do in order to promote teacher reflection and shifts in instructional practice?

In order to better understand this, I also seek to answer the following sub-questions: What are the questions, statements, and moves that coaches make to support teacher thinking and instructional planning around mathematical tasks of teaching? What are the contextual factors that influence the work of the coach with classroom teachers and how do such factors influence the moves that coaches make with classroom teachers? Developing a better understanding of how coaches enact reflective coaching conversations and the issues that influence the practice of mathematics coaches can help to inform the field on how to better train and support coaches in their collaboration with classroom teachers.

Chapter 2

A Review of the Literature on Mathematics Coaching

This chapter provides an examination of the existing research around mathematics coaching to create a picture of what is known about the role and effectiveness of coaches, and where additional research is needed to better understand the work of instructional coaches. The chapter begins with a discussion of studies that looked at the effectiveness of coaching at broad, programmatic levels, then shifts to literature that helps to define the "what" and "how" of mathematics coaching roles that are argued to lead to effective coaching practice. From there, the lens of the discussion narrows to focus on the existing literature around the types of coaching moves and what is known about how these moves influence the work of coaches in less and more productive ways. Finally, the closing section of the chapter examines the literature on contextual factors and the influence such factors may have on the work between mathematics coaches and classroom teachers.

Examining the Literature on Coaching from a Programmatic Level

Multiple definitions and models of coaching exist, and studies have been conducted looking at a variety of factors related to the potential effectiveness of endorsing this form of professional development. Many early studies focused on the work of literacy coaching. Now mathematics and science content coaching are being examined as well. Much of the recent literature indicates that "deep coaching," the roles of the coach that involve the three part coaching cycle, holds the greatest potential to make shifts in mathematics planning and teaching that can positively impact student learning (Mudzimiri, Burroughs, Luedbeck, Sutton, & Yopp, 2014; Saphier & West, 2009). In their study of literacy coaches, Bean, Draper, et al. (2010) found that coaches only spent about 55% of their time on more in-depth activities in their collaborative efforts with teachers. If “deep coaching” represents little more than half of where coaches spend their time and energy, understanding how to maximize the effectiveness of this time spent with teachers is critical.

Other studies have had less straightforward findings about the effectiveness of coaching. Although Murray, Ma and Mazur (2008) found that while teachers reported positive experiences with coaching, there was little depth to the mathematical discussions teachers had with coaches and no connection to improved student achievement could be made. One unique feature of their study was the implementation of a “peer coaching model,” where teachers who received training on mathematical content and pedagogy “coached” one another in planning and debriefing sessions. At times, peer coaching, though described as a positive experience for participants, led to descriptive rather than reflective conversations about teaching. Such conversations tended to describe teaching situations rather than analyze teaching practices and student learning in order to consider ways to adapt or improve mathematics teaching practice.

In their study on coaching interactions with classroom teachers, Olson and Barrett (2004) also had mixed results. Despite the fact that researchers worked with teachers as knowledgeable others to implement a mathematics curriculum focused around reasoning and problem solving (NCTM, 2014; Schulman, 1986), teachers did little to change their instructional practices. The authors suggested that coaching, on its own, was not enough to help teacher learners improve. Atteberry and Bryk (2010) found varying results in different coaching situations with regard to how often and with whom teachers collaborated around literacy instruction. Neuman and Wright (2010) reported that coaching had only a modest effect in fostering shifts in teachers' practices, and Ross (1992) was unable to draw clear conclusions about whether the work of the coach with classroom teachers can be tied to student achievement. Such studies suggest that what coaches *do* in this deeper coaching practice with classroom teachers needs to be more closely examined in order to better understand why three part coaching is not always as effective as coaching initiatives intend in helping teachers learn to enact reform-oriented teaching practices.

When looking at coaching studies that have demonstrated positive effects, certain details about the role of the coach stood out. Biancarosa, Bryk, and Dexter (2010) and Campbell and Malkus (2014) found that coaching did not immediately translate to an effect on student achievement but did over time, as the coaches learned to negotiate their role and develop experience. In another study, Matsumura, Garnier, and Spybrook (2012) found that coaching resulted in student achievement gains when coaches received adequate professional development and their roles were well defined and focused. Additionally, these coaches did not have additional administrative duties and focused their attention somewhat intensively with a select subset of teachers in the schools on targeted strategies. Such role refinement allowed coaches to focus their energies in meaningful ways with a small sample size of teachers that promoted ongoing conversations about teaching practice.

Other studies found that when there was an explicit focus on instructional strategies or pedagogical moves during coaching sessions, coaches could help teachers make impactful changes to their mathematics teaching over time. Guiney's (2001) look at early coaching initiatives in a public school system showed evidence of student achievement gains in schools where coaches had been placed the longest. In her study, coaches worked with teachers to analyze student work for evidence of students' mathematical understanding, and to find ways to present mathematical content that were engaging and helped students use multiple approaches for solving (Fuson, Kalchman, & Bransford, 2005), much like the reform based teaching practices promoted by NCTM (2014). These teaching practices align with several of Ball, Thames, and Phelps' (2008) mathematical tasks of teaching, including "Giving or evaluating mathematical explanations," "Presenting mathematical ideas," and "Linking representations to underlying ideas and other representations."

Peterson et al. (2009) found that coaches who received substantive professional development and had certain organizational structures in place fostered shifts in teaching practice and growth in student learning. These coaches utilized protocols to guide conversations and deep reflection with teachers, and, similar to Guiney's study, coaches helped teachers to analyze student data. This coaching work helped teachers to consider worthwhile tasks of teaching such as "Evaluating the plausibility of students' claims" and "Giving or evaluating mathematical explanations" (Ball, Thames, & Phelps, 2008). Additionally, Walpole et al. (2010) found that when instructional coaches had frequent and active support from building leadership there was a significant relationship to improvements in teaching. Coaching is not a linear process, however, and so judging the effectiveness of coaching programs is a difficult and complex task, even over time (Anderson, Feldman, & Minstrell, 2014). Although it is beyond the scope of the current study to examine the effectiveness of coaching programs, this study seeks to better understand the specific features of coaching work during the three part coaching cycle that can inform the design and implementation of future coaching programs.

The "What" of Mathematics Coaching

Although there is literature to support what coaches should do to help teachers develop their capacity to teach reform based mathematics, seldom does the literature focus on what it actually looks like when such coaching conversations occur. The stakes are high for coaching to act as a mechanism by which mathematical and pedagogical knowledge and high leverage teaching practices are transferred into teaching practice in classrooms. Costa and Garmston (2002) suggested that coaches must adapt their practice to meet the various personalities and needs of the individual teachers with whom they work. Campbell et al. (2013) described *what* is necessary for good coaching, moves such as: focusing on practices that enhance teacher knowledge; modeling, co-teaching, and reflecting on the incorporation of these practices into instruction; and helping teachers carefully design tasks and questioning strategies for the lesson. Helping coaches develop an understanding of *how* to develop these coaching moves effectively is an important area of need to inform the field in ways that can improve the effectiveness of coaching initiatives.

Resources for coaches such as *Mathematics coaching: Resources and tools for coaches and leaders, K-12* (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014) offer suggestions about *what practices* to focus coaching on. Such areas include: content knowledge and worthwhile problems, instructional strategies, questioning and math talk, utilizing formative assessment, analyzing student data, differentiating and scaffolding instruction, and working with special student populations. The authors give examples of how and what types of questions coaches should pose that help teachers to consider things like students' prior knowledge ("What have students learned about this topic already?"), or anticipate student strategies during the lesson ("How might students solve this problem?"), as well as questions that focus around mathematical goals and the set up and design of mathematical problems. My study will focus on developing a better understanding of how and what coaches choose to focus on in planning conversations with teachers in order to help teachers attend to reform-oriented practices.

Bearwald (2011) explained that effective questions are precise, generate specific information, and help to connect the past, present and future. Examining the types of questions posed and ideas offered by coaches in the context of planning and teaching the mathematics can offer insights as to whether or not these "coaching moves" play out in practice as suggested by such resources. Potentially, such an examination could also offer a better understanding of the implications of coaching conversations where these moves do not play out as intended or suggested. There is a need to develop a clearer picture of what it looks like when coaches attempt to engage in this deeply reflective practice to better understand how to train and support coaches to do this work effectively with classroom teachers.

It is important for the field to better understand what it is that mathematics coaches do during these coaching conversations to move teachers toward reflecting on mathematical tasks of teaching in order to become more responsive in their practice. Of all the coaching roles, one of those that holds the most potential to do this include that of the classroom supporter. Killion (2008) described this role as when coaches are in classrooms with teachers to observe, model, and co-teach lessons, as well as to conference prior to and after lessons to help teachers plan and reflect to improve instruction. The three part coaching cycle is an important feature of coaching that allows the mathematics coach to interact one-on-one with classroom teachers in a focused and purposeful setting. This cycle can act as a platform by which to study the moves that coaches make when they are collaborating with teachers to improve their instructional practice and positively affect student learning. Examining the ways coaches facilitate these cycles- the questions they pose, the suggestions they give, the resources they provide- can help inform what it is about the practice of coaches that helps teachers attend to mathematical tasks of teaching in reform-oriented ways during their planning and instruction.

When coaches listen, question, push for shifts in instructional practice, support lesson planning, gather data, and help to deepen teachers' content and pedagogical knowledge during coaching cycles, they do so in both subtle and overt ways. Understanding the ways coaches negotiate between being responsive to teachers' needs and directing, pressuring, and persuading teachers to utilize key strategies and resources can provide much insight into what effective coaches do (Ippolito, 2010). It is this *how* of coaching during the three-part cycle that needs to be further examined. My study seeks to better understand the "moves" that coaches make to promote teacher reflection and analysis of their own practice in ways that help them shift that practice toward reform-oriented teaching.

The "How" of coaching: Professional Development and Knowledge of Mathematics

In order to help push teachers to reflect on and analyze their instructional practice, mathematics and other instructional coaches must have many types of knowledge, in some instances knowledge that is different from that which they needed as classroom teachers. Sutton, Burroughs, and Yopp (2011) developed eight "domains of knowledge" for coaching to help researchers, professional developers, and coaches themselves understand how to better maximize the potential effectiveness of mathematics coaching. The domains the researchers described include: assessment, communication, leadership, relations, student learning, teacher development, teacher learning, and teacher practice. Although it is important for mathematics coaches to have an expansive knowledge base, further understanding as to how coaches help teachers attend to mathematical teaching tasks during coaching conversations can inform the literature on what it looks like for coaches to do so effectively.

Chval et al. (2010) described mathematics coaching as having "…the potential to influence the professional growth of teachers…if novice mathematics coaches are supported to develop the knowledge base that is necessary to engage in coaching effectively" (p. 193). Many times, as coaches transition into their new roles they must develop new domains of knowledge to enact their work with teachers effectively. In order for coaches to do this well, the training and supports offered to coaches, much like those for teachers, play an important role in cultivating skilled practitioners over time. If schools want strong mathematics coaches, they must understand the complex nature of the role to develop support systems that can adequately address the needs of these teacher leaders. One set of challenges that districts face in providing training for coaches involves the difficulty finding experienced persons to provide this support due to the newer nature of content-focused coaching (Neufeld & Roper, 2003). Districts often have to "grow their own" coaching expertise, which at times can be inadequate, leading to variance in how coaching is enacted in different settings. When coaches receive training in coaching knowledge domains (Sutton, Burroughs, & Yopp, 2011), and are provided ongoing supports to develop and refine a repertoire of coaching moves, mathematics coaches can potentially enact their role with a common vision and level of expertise.

In some studies, this disparity in training has led to the failure of coaching models. Fullan and Knight (2011) described a coaching program that was abandoned within two years due to the lack of coherent structures necessary to support effective coaching. Mangin and Stolinga (2011) suggested that often the work of coaches started somewhat superficially to build trust, but at times coaches lacked the skills to transition to deeper conversations around teaching mathematics. Conversely, when coaches were provided comprehensive training and supports, positive outcomes have been reported in a variety of research studies. Anderson, Feldman, and Minstrell's (2014) study of science coaches indicated that, with support, coaches were able to translate their professional learning to collaborative practice with teachers over time, and literacy coaches involved in a district-wide initiative had a substantial impact on student learning over time (Biancarosa, Bryk, & Dexter, 2010). The latter study emphasized the robust professional development for coaches, the articulation of a clear vision for the coaching role, and the use of three-part coaching cycles as being a critical feature of the coaching role. In a coaching initiative that Guiney (2001) followed, the school district revised their initial plan to phase out coaches after two years when they recognized the impact coaching was having on instructional practice and schoolwide improvement. It is imperative to understand the features of the roles of coaches that can lead to such divergent results in the literature.

Specifically with regard to mathematics coaches, a series of studies have suggested that providing professional development in both mathematical content and pedagogical knowledge, then allowing time for coaches to develop experience, resulted in significant student achievement gains over time (Campbell & Malkus, 2011; 2014). Brosnan and Erchick (2010) likewise sought to determine whether mathematics coaching had a positive impact on student achievement and found effect sizes ranging from .52 to .87, which indicated a strong positive impact from coaching. Their study also had a robust framework for developing domains of coaching and teaching knowledge within their mathematics coaches before beginning their collaborative practice with classroom teachers. In this study, coaches focused on developing research-based teaching practices with teachers that focused on student thinking and learning. This connects both to the practices endorsed by NCTM (2014) and the broad categorizations of the mathematical tasks of teaching I refer to in Chapter 1 of focusing around mathematical goals, student thinking, and the design of problems and lessons (Ball, Thames, & Phelps, 2008). Similarly, in their comparative study, Zollinger et al. (2010) found that mathematics coaches with substantive training that supported research based practices had a moderate to significant impact on student achievement in five out of six grades analyzed. Although the latter study did not detail the focus of coaching work, both of these studies indicated the potential for mathematics coaches to have positive effects on not only teacher practice, but student achievement as well, when the role was enacted effectively. Such research highlights the importance of my current study in developing a better understanding of what productive coaching moves look like that can help move teaching practice forward.

Enacting "Deep" Coaching of Mathematics and Mathematics Teaching in Practice

When coaches are provided adequate professional training and support, it is more likely for their collaboration with classroom teachers to be effective in moving teacher practice toward reform-minded efforts (Campbell & Malkus, 2011; Zollinger, Brosnan, Erchick, & Bao, 2010). It is important for coaches and those who work with and provide professional development to coaches to develop a clear picture of what effective coaching looks like in practice. Costa and Garmston (2002) described the important features of coaching as developing lesson goals, anticipating teaching strategies and student thinking, and pushing teachers to analyze data and reflect on teaching decisions. Such features reflect the reform-oriented teaching practices highlighted by NCTM (2014) and much of the current literature of mathematics instruction (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell & White, 1997; Huguet, Marsh, & Farrell, 2014; Smith & Stein, 2011). Fullan and Knight (2011) suggested a list of "actions of a good coach," which included helping teachers to identify clear goals, engaging in active listening to understand the teacher's perspective, asking good questions, and providing structures for collaborative discussion. This list is well-aligned with the broad categorizations of mathematical tasks of teaching from Chapter 1, particularly around developing mathematical goals, considering problem design, and using evidence of student thinking to drive instructional decision-making.

It is critical then, for mathematics coaches to understand what it looks like to focus their coaching moves around these mathematical tasks of teaching well. Little of the current literature on mathematics coaching provides the type of descriptive evidence that would help mathematics coaches and those tasked with preparing them for work that entails deep coaching around mathematical tasks of teaching. In one of several reports on their study of mathematics coaches and the potential for coaching to impact student achievement, Campbell and Malkus (2014) provided an overview of what this sort of coaching looks like in Figure 1. The framework presented in Figure 1 represents the interactions of the mathematics coach and classroom teacher as they engage in the three part coaching cycle.

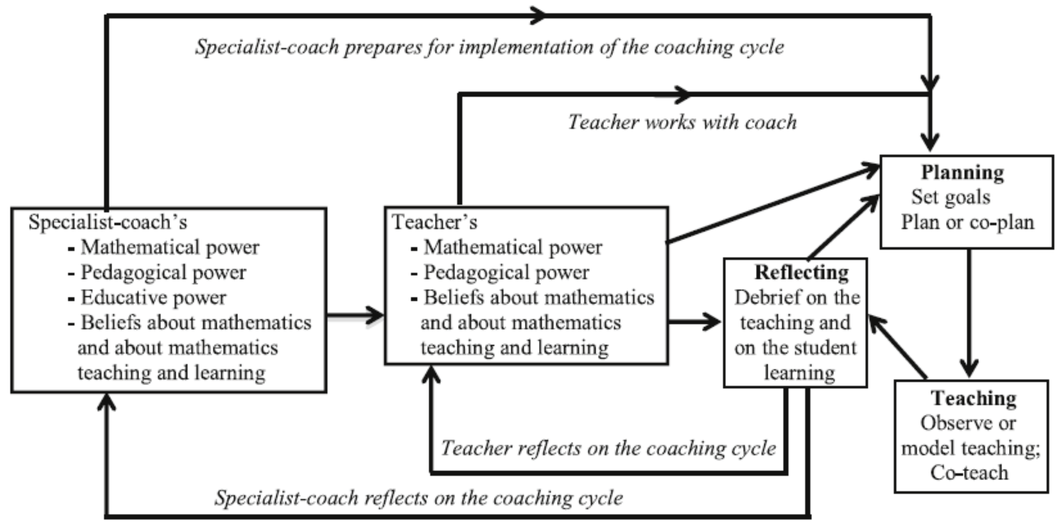

Figure 1. Conceptual framework of the work of coach and teacher throughout the coaching cycle (Campbell & Malkus, 2014).

In their work, Campbell and Malkus explained *mathematical power* as "…knowledge of mathematics content as well as skillful design of activities or tasks to engage students in learning mathematics" and *pedagogical power* as "…knowledge of mathematics teaching as well as facility with developing or altering approaches for teaching mathematics" (p. 216). Ball, Thames, and Phelps' (2008) mathematical tasks of teaching could be imagined within the box that illustrates the teacher's mathematical and pedagogical power in Figure 1. These teaching tasks are the sorts of content related items that teachers must consider when attempting to design activities and to become flexible in adapting such activities in the moment to respond to the needs of student learners. They are part of the mathematical and pedagogical power of the teacher. Although the specialist-coach box in Figure 1 also includes knowledge and facility with these teaching tasks, coaches must possess an additional layer of pedagogical power in learning to facilitate conversations with teachers that help them attend to this range of teaching tasks. This layer includes moves that are unique to the coach to engage teachers in learning how to develop a reform-based teaching practice.

Campbell and Malkus' (2014) study demonstrated the potential for mathematics coaches to positively impact student achievement, but their study did not dig into the qualitative side of "what" and "how" coaches do what they do in ways that inform the role of mathematics coaches to maximize their effectiveness. In order to better understand and situate the importance of the current study, it is essential to consider what has already been learned about the practice of mathematics coaches, as well as what still needs to be addressed to strengthen the existing body of literature. To help teachers reflect on mathematical tasks of teaching in their practice, coaches must understand what "deep coaching" looks like and how to determine what to focus on in coaching conversations with teachers. In considering this additional layer of "pedagogical power" in Figure 1 (Campbell & Malkus, 2014) that mathematics coaches must have to facilitate productive conversations with classroom teachers, there is much to be learned about what this layer looks like. The focus of my study is to examine the types of coaching moves that are necessary to help teachers shift their mathematical and pedagogical power in a manner that helps teachers attend to mathematical tasks of teaching in reform-oriented ways.

Biancarosa, Bryk, and Dexter (2010) described the main goal of coaching as to "…work one-on-one with teachers in their classrooms; observing, modeling, and catalyzing teachers' development toward more expert practice" (p. 10). In a study by the Literacy Collaborative initiative, researchers considered this form of coaching the most "high leverage activity" through which coaches helped teachers implement effective pedagogical practice. Unfortunately, this study did not examine specifically what the coaches said and did in one-on-one sessions, rather it provided an analysis on how student achievement changed over time during the initiative. The researchers found significant gains in student achievement the first year, and this number grew each subsequent year of the study, indicating that coaching in such a focused way could positively impact student learning over time. Campbell and Malkus (2011) reported on a study of mathematics coaching where the coaches were provided extensive training on mathematical content, pedagogy, and teacher leadership before three years of data collection and analysis. The study findings indicated that students in schools with coaches scored significantly higher than students in comparable schools without coaches in place. Further, the study found that these gains remained stable or, in some cases, increased beyond year one of the study. Neither study reflected the details of the deep coaching process that may have led to these gains, indicating the need for further research.

Campbell et al.'s (2013) published resource book for mathematics coaches suggested that coaching should be focused on increasing teachers' mathematical content knowledge, use of high leverage teaching strategies, questioning and mathematical discourse, and analysis of student data. In their study of literacy coaches, Vanderburg and Stephens (2010) interviewed teachers who engaged with coaches and found that teachers valued how coaches attempted to set up collaborative relationships, provided ongoing support, and helped teachers learn about research-based instructional strategies. Matsumura, Garnier, et al (2010), Masumura, Garnier, Resnick (2010), and Matsumura, Garnier, Spybrook (2012) found in their study of literacy coaches that over time teachers participated more frequently in coaching focused on deeply planning and reflecting in ways that helped teachers attend to research based literacy practices. Such findings appear to align with the coaching strategies that the professional literature on coaching highlights (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013), at least in a broad sense.

Several studies in recent years have made connections between mathematics coaching and increased student achievement (Brosnan & Erchick, 2010; Stewart, 2013). Although these quantitative studies reported a connection between teachers collaborating with mathematics coaches and gradual student achievement gains, neither offered descriptive evidence as to what it was about the coaching process that may have led to such increases. Such studies suggested that teachers see coaching as beneficial when done well, yet they did not provide examples of what this looked like or meant in ways that could support professional development and training for other coaches. Besides the content focus on literacy rather than mathematics in these studies, all of this research was quantitative or mixed in nature. There was no qualitative evidence to help make visible *what* it looks like when coaching is productive for future coaching practice to build off of such findings. Although these studies suggested positive results with regard to instructional coaching, few studies provided detailed evidence as to the specifics of the coaching moves that were more or less productive in promoting deep reflection and conversation with classroom teachers.

There are studies that have reported on some features of coaching that could potentially influence the productivity of coaching conversations during the three-part cycle. Berg and Mensah's (2014) study on science coaches found that the extent of time teachers were willing to spend with coaches related to their approach in addressing instructional issues in either reform oriented or non-reform oriented ways. In terms of their study, "reform-based" teaching in science included many similar teaching practices as are advocated for in mathematics education, including: making connections and themes apparent, teaching for depth and conceptual understanding, engaging students in inquiry and problem solving, and engaging students in discourse where they must learn to make and defend scientific claims. This supports the idea that in mathematics educational research, helping teachers attend to mathematical tasks of teaching such as consideration of "Presenting mathematical ideas," "Linking representations to underlying ideas and other representations," "Evaluating the plausibility of students' claims," and "Asking productive mathematical questions" cold help to increase teacher use of reform-oriented teaching practices. These mathematical tasks of teaching, much like the science teaching tasks, focus on reformed oriented practices such as the setup of mathematical problems in ways that promote productive struggle and student discourse (Smith & Stein, 2011; Stein, Smith, Henningsen, & Silver, 2009) and the use of high leverage questions that foster discussion and help students make connections between representations and big mathematical ideas (Boaler & Brodie, 2004).

In their 2010 study, Walpole et al. described the importance of coaches coming into these conversations with a "coaching goal," a specific target they wanted to focus on with the classroom teacher during the coaching cycle. A unique feature of this study was the administration of surveys, which the researchers used to determine 1) the level and effectiveness of collaboration, 2) the extent to which coaches pushed for differentiation, and 3) the extent to which coaches maintained the support of their administrators. Unfortunately, the paper did not give examples of *how and what* coaches said and did to do each of these things, or what was included in the survey, to give readers a descriptive sense of what productive versus less productive coaching looked and sounded like in practice. Much of the professional literature on coaching (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013; West & Staub, 2003) support both the idea of coaches setting goals and coaches helping teachers to set mathematical goals that are aligned with reform-oriented practice (NCTM, 2014).

Similarly, Hsiesh et al. (2009) presented a study where literacy coaches focused on three specific research-based clusters of early literacy instructional strategies with teachers, to determine to what extent in-class coaching impacted the teachers' use of these strategies in their practice. Coaches were given a sequence of coaching supports to use during a three-part coaching cycle that focused on training the teacher how to attend to and use a target strategy, then observing and providing feedback on implementation of the strategy during the lesson. All of the teachers who collaborated with coaches increased their use of the targeted strategies. However, there was some variability across the teachers in the sample as to the extent that the strategies were employed during and beyond the coaching intervention. Although the study found an increase in teachers' use of the literacy strategies after coaching was employed, all of the teachers in the study had educational backgrounds in teaching early childhood literacy that may have influenced their willingness to implement the new strategies. This is not always true of elementary mathematics teachers, nor did this study go into specifics as to whether the ways in which coaches enacted these protocols influenced the extent to which the coaching influenced shifts in teaching practice.

My study seeks to focus on the specific moves mathematics coaches make, as well as how the enactment of such moves promote teachers' ability to attend to mathematical tasks of teaching in ways that lead to reform-based teaching practice in mathematics. This will add to the existing literature a new understanding of the specific aspects of coaching moves that lead to more or less productive coaching work with classroom teachers around the promotion of implementing and analyzing reform-oriented mathematics teaching practices.

The "Coaching Moves" at the Heart of Mathematics Coaching

Throughout the current literature on mathematics coaching (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013), there are broadly referenced actions that coaches use to foster conversations with teachers that are reflective and analytical of both the mathematical content presented to students and teaching practice. A unique feature of a study on mathematics coaching by Mudzimiri, Burroughs, Sutton, and Yopp (2014) was the use of an observation protocol to guide data collection. Their findings supported much of the professional literature on mathematics coaching, which suggested that coaches should focus their energy on content and pedagogical issues, on monitoring and analyzing student data, and on the reflection of mathematical teaching practices (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013). In their analysis, Mudzimiri et al. categorized coaching practice into three types of strategies coaches employed: relational strategies, exchanging information, and facilitating teacher learning.

Another study by Huguet, Marsh, and Farrell (2014) utilized a framework to categorize major coaching practices as: assessing teacher needs, modeling and observing, providing feedback and sharing expertise, engaging teachers in dialogue and posing reflective questions, and attempting to foster communities of practice schoolwide. This study found differences in the coaching observed, leading to an examination of strong coaches versus developing coaches in order to determine which coaching actions seemed to most strongly influence teacher practice. The researchers described their findings on these differences, stating, "While both strong and developing coaches enacted these practices, they differed in the variety and frequency of practices employed…strong coaches employed a broader range of practices with more frequency than did their developing counterparts" (p. 13). The researchers further found that coaching interactions were impacted by the types of artifacts the coaches used with teachers. Strong coaches tended to provide scaffolding that allowed teachers to access tools on their own, as well as went into more depth analyzing data/tool use, and they applied more reciprocity and collaboration in setting norms with teachers. Although both of these studies offered insights at a broad level as to the sorts of work that coaches do, they did not break down more specifically examples of the types and range of coaching moves that coaches utilized to help teachers attend to these mathematical and pedagogical topics. My study looks to uncover the specific types and frequencies of coaching moves utilized by mathematics coaches to better understand this range of coaching moves that can be employed to influence mathematics teaching practice toward reform-oriented instructional approaches.

Mangin and Stolinga (2011) described the need for coaches and teachers to be able to have “challenging but meaningful conversations” about teaching (p. 50). Like other experts, they emphasized the importance of this practice, which is complex in nature. One of the missing pieces in the literature is an understanding of how coaches attempt to negotiate reflective conversations in ways that maintain the trust and rapport needed to foster productive discourse with teachers. During the three part coaching cycle, mathematics coaches often engage in a variety of “coaching moves” that attempt to help teachers learn to attend to the broad range of mathematical tasks of teaching and reform oriented teaching practices that the literature suggests (Beckmann, et al., 2012; NCTM, 2014) needs to occur. It is important to understand the topics and ideas that coaches focus on in these discussions with teachers and how they approach certain topics throughout the conversation. Understanding how and what coaches do to engage teachers in these challenging conversations is a goal of my study to help the field better understand which coaching moves have the potential to be most productive. My study also seeks to help coaches and those who support coaches recognize the types of factors that may influence how and when such moves are enacted during substantive coaching conversations in ways that are more and less productive.

Studies that include categorization of coaching actions can help to give coaches and those who work with coaches an idea of the ways that are most productive to focus on substantive conversations with teachers. There is still a need to better understand how coaches negotiate using a variety of strategies in the context of their work with individual teachers to move the coaching cycle forward productively. In order to develop strong coaches, it is critical to understand which of these coaching practices hold the most potential to leverage conversations around effective teaching practices during coaching cycles. To do this, it is important to clearly define "coaching moves" in terms of my study. During the coaching cycle, coaches tend to engage teachers in activities such as posing reflective questions, sharing expertise or offering suggestions around mathematical content and teaching practices, actively listening and paraphrasing, and promoting analysis of data and student data in their planning and debriefs with teachers (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013; Huguet, Marsh, & Farrell, 2014). Understanding how these moves play out in various coaching conversations in ways that are more and less productive, as well as how these moves interact with one another can inform the field as to how coaches can enact a range of coaching moves more productively. My study looks to examine these moves in detail in order to determine what makes for productive coaching around helping teachers attend to reform oriented mathematics teaching practices.

Promoting Reflection and Analysis through Questioning

Campbell et al. (2013) described effective professional development and coaching as promoting reflection that focuses on student understanding and learning in an effort to hone and potentially modify teaching practice in reform-oriented ways. Likewise, Lin et al. (2014) found that teachers reported collaborative reflection as the most helpful component of revisiting their lessons to refine their inquiry-based teaching practices. Their study also found that teachers increased the use of effective strategies, such as using higher level questioning, when they participated in collaborative reflection. Saylor and Johnson's (2014) meta-analysis on teacher reflection found that providing both formal and informal reflection activities for teachers led to shifts in teaching practice. These studies highlight coaching that focused on mathematical tasks of teaching such as "Evaluating the plausibility of students' claims," "Giving or evaluating mathematical explanations," "Asking productive mathematical questions," and "Responding to students' 'Why?' questions" (Ball, Thames, & Phelps, 2008). This also indicates the power that reflection can hold in helping teachers consider their instruction at a deep level and determine how to move their teaching practices forward in ways that improve student learning. One coaching move that can foster such reflection is the posing of open-ended and well-crafted questions during the coaching cycle.

Murray, Ma, and Mazur (2008) found several trends in their study of peer coaching: 1) that reflections on teaching tended to be more descriptive than analytical, 2) feedback and discussion remained positive across their data, 3) both parties shared equally in the conversation, and 4) like Mangin and Stolinga (2011), found that most conversations did not attend to content or student thinking. This seems to support the notion that coaches need knowledge of evidence based approaches to enact coaching conversations in ways that push for reflection and analysis of teaching practice. They must incorporate coaching moves that focus on deepening the conversation and narrow in on issues that get at the heart of mathematical tasks of teaching during the three part coaching cycle. Feger, Woleck, and Hickman (2004) said that the ways in which coaches questioned teachers during the coaching cycle altered the effectiveness of coaching. They explained that questions should be focused on reflection of curriculum, examination of student thinking and learning, articulated as open ended and non-critical in nature, and that the timing and delivery of questions mattered.

Professional resources for mathematics and instructional coaches have suggested that teacher reflection and shifts in teaching practice stem from posing intentional questions that push the teacher's thinking (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013). Further research needs to be done to better understand the sorts of questions coaches ask, as well as how and when they do so in order to recognize the features of coaching conversations that can best promote deep reflection and analysis of practice. Examining how such questions are posed within the contexts of three part coaching cycles can shed light on what coaches can do to productively collaborate with teachers. Recognizing not only the types of questions that coaches use, but also the patterns of questioning that are more and less effective in helping teachers attend to mathematical tasks of teaching, can help to inform the current understanding of what makes some coaching practice more effective than others. Much like teacher questioning in mathematics education, if coaches use focusing rather than funneling patterns of questioning (Herbel-Eisenmann & Breyfogle, 2005), they can help teachers make connections to reform-oriented practices and mathematical tasks of teaching.

Peterson et al. (2009) described a study where the literacy coaches had training on the content and pedagogical practices that were the goal of the reform, as well as on how to conduct coaching conversations that were productive with teachers. Unlike most of the literature referenced earlier in this section, the paper *did* give examples of times during the conversation where the coach posed a series of questions from a protocol to generate a reflective discussion with the teacher on a specific aspect of the lesson. The authors claimed that the coaches engaged in focused and productive conversations as a result, which allowed teachers to deeply reflect on their incorporation of effective teaching practices in their literacy instruction. Understanding how these questions were asked and how the resulting conversations played out in literacy is a starting point for gaining a sense of what it could look like in mathematics coaching, however it is difficult to find examples like this in the current body of literature related to mathematics.

At times, studies have shown evidence of questioning by coaches that were more effective, however a variety of factors may be at work in how this coaching move played out according to some of the research. In their study of literacy coaches, Bean et al. (2010) found that coaching conversations tended to focus on analyzing data and using it to inform instruction and differentiated groups for student work. Despite the fact that these conversations happened often and attempted to have coaches help teachers problem solve instructional issues, the researchers almost never saw the entire three part coaching cycle enacted. If debriefs occurred, they were extremely brief, maybe five minutes long. Such data seems at odds with what the experts in the field recommend for effective coaching practice when working one-on-one with classroom teachers (Costa & Garmston, 2002; West & Staub, 2003). If the debrief did not occur, there was no opportunity for coaches to help teachers reflect on their practice in ways that could inform their next steps instructionally.

Olson and Barrett (2004) presented a case study where the researchers engaged in five cycles of cognitive coaching over a three-week period with three classroom teachers. The study offered a few insights into the types of reflective questions the "researcher-coach" posed to one of the teachers in order to push reflection on the mathematics and her students' mathematical understanding. However, the researchers reported the teacher often deflected these attempts and focused on less substantive aspects of the lesson initially. The study concluded with the finding that, although the teacher participated in training on the use of reform based mathematics curriculum *and* had the support of an instructional coach, she still engaged in using the materials in more "traditional" ways. The researcher explained that the teacher described the new strategies as "…'too time consuming' and resumed her practice of 'showing and telling' because it was 'more efficient and students mastered their facts quicker'" (p. 73). These findings indicate that even when teachers are open to collaborating with coaches and engage in conversations where coaches use high leverage coaching moves, such as questioning to foster reflection, shifts in practice do not always occur. Developing a better understanding as to what it looks like when teachers do not attend to mathematical tasks of teaching and how coaches attempt to negotiate such challenges is an area that needs to be further examined by research. My study seeks to examine instances where this occurs and how coaches employ coaching moves that do and do not help teachers attend to mathematical tasks of teaching and reflect on reform-oriented teaching practices when such initial resistance occurs.

Focusing on Mathematical Tasks of Teaching through Sharing of Expertise and Data

One of the goals coaches often have in their discussions with classroom teachers is to promote reflection and analysis of teaching practice that moves teachers toward reform based mathematics instruction and a focus on mathematical tasks of teaching (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014). In an effort to help coaches organize their coaching practice, McGatha and Bay-Williams (2013) presented a framework for teacher leaders to utilize to help teachers incorporate the mathematical practices into their teaching. This framework began with the idea that teacher leaders must help teachers envision what such practices look like, encourage them to consider making shifts in current practice, and help teachers reflect on teaching practices that foster these shifts. Although this article offered example questions for coaches to ask related to each of the seven shifts in mathematical teaching practices (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014), the authors did not talk about how to address teacher responses in the moment, or where the coach should go next to move the conversation forward productively.

In their study, Barrett et al. (2002) described the role of the coach as attempting to help teachers develop strategies to incorporate worthwhile mathematical problems in lesson design, ask higher level questions, and better attend to and promote students' mathematical thinking. These strategies align with both NCTM's (2014) suggestions for reform-based teaching practices as well as the mathematical tasks of teaching around problem design, posing purposeful mathematics questions, and evaluating student claims and explanations (Ball, Thames, & Phelps, 2008).The study offered a description of three supports the professional developers offered to scaffold the conversations with teachers in this part of the study. In the article, it was challenging to see how the coaching moves played out in the moment. No detailed analysis of the coaching moves occurred in the study, rather the focus was on the teachers' lack of shift in teaching practices. It is hard to know what sorts of specific ideas and suggestions the coaches may have tried to employ to foster these shifts in practice. This information is necessary to better understand why these coaching moves may or may not have been successful in the various coaching situations throughout the study. Little of the current literature highlights the types of ideas that coaches offer to teachers in reflective coaching conversations, leaving lingering questions as to what it looks like to productively move teachers to consider mathematical tasks of teaching.

In their study of teacher instructional rounds, Troen and Boles (2014) described five core assumptions about how to foster professional growth for teachers. These included: making the teaching practice collaborative, collecting concrete data to back up assertions about effective teaching and learning practices, and the idea that teachers who are self-reflective become more effective. According to Peterson et al. (2009), "Coaching for self-reflection is a collaborative model in which the coach and the teacher work in partnership to make more effective decisions about classroom instruction" (p. 501). They found that the use of concrete evidence from enacted lessons, in conjunction with questions and content focused conversation, led to deeper reflection on lessons by the teachers.

Mathematics coaching resources, such as the one written by Campbell et al. (2013), have suggested the importance of sharing examples of students' mathematical thinking to help teachers make mathematical connections and consider where to go in the next lesson. There is no readily available research on what it looks like for coaches to share such data in order for coaches to understand *how* sharing data can lead to making connections or focus planning for future instruction. Collecting and sharing data in and of itself is not necessarily enough to foster reflection, therefore, it is crucial to understand what coaches do with this evidence to focus conversations around incorporating mathematical tasks of teaching both into reflections and future planning. My study examines instances of this coaching move of collecting and sharing data/evidence to better understand how coaches attempt to use this move to foster teacher talk and reflection around mathematical tasks of teaching in their practice.

A Missing Link in the Literature on Coaching Moves

The literature on deep mathematics coaching with teachers is a growing body of work (Brosnan & Erchick, 2010; Campbell & Malkus, 2011), and there is still much to be better understood. Studies such as the one conducted by Bruce & Ross (2008) support the thought that teachers do more explicit self-reflection because of their interactions with coaches. Similarly, Lin et al. (2014) found that these reflective conversations on teaching acted as a facilitating agent in fostering instructional shifts in science teaching. As the previous sections have illustrated, researchers and professional writers in the field tend to agree that asking intentional and well planned questions is important, and that promoting teacher reflection, analysis, and synthesis during all phases of the coaching cycle is key (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013; Olson & Barrett, 2004). Despite this importance, it can be difficult to tie teacher reflection directly to shifts in instructional practice. Better understanding the moves that coaches use to promote this self-reflection can help researchers gain a better sense of what these coaching moves look like and practice and the extent to which they promote teachers' attention to mathematical tasks of teaching in planning. My study looks to identify the types and frequency of the specific coaching moves utilized during the three part coaching cycle in an attempt to foster teacher reflection and analysis around mathematical tasks of teaching.

As well as examining the "coaching moves" and how they played out in the context of different coaching conversations, little of the existing literature has deeply examined the content within which this dialogue and coaching practice was situated (Barrett, et al., 2002; Mudzimiri, Burroughs, Luedbeck, Sutton, & Yopp, 2014). It is hard to determine from the existing studies which topics and domains of knowledge coaches focused on most often (Barlow, Burroughs, Harmon, Sutton, & Yopp, 2013), or whether particular topics were more productive in fostering shifts in teacher thinking and practice than others. Additional studies are needed to examine how coaches tend to negotiate determining what to focus on in the moment, and how well they maintain a productive focus when engaging with a variety of classroom teachers. There are many skills that professional books on mathematics coaching suggest coaches should focus on with teachers (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013; West & Cameron, 2013), however at times it is unclear which ones coaches tend to spend the most time on with teachers and why. In my study, I examine the types and frequencies with which coaching moves help teachers attend to a range of mathematical tasks of teaching, and attempt to develop an understanding of potential trends and patterns in the focus of these reflective conversations.

It can be equally unclear in the current body of research what some of the potential factors are that may influence those decisions from teacher to teacher and coach to coach (Mudzimiri, Burroughs, Luedbeck, Sutton, & Yopp, 2014). Another gap in the literature is that, despite the growing body of research examining the content of deep coaching practice, little of it has been focused on mathematics, and less still on how these coaching moves play out in planning and enacting elementary mathematics instruction. It is important to address this missing component of the literature by focusing on the practice of elementary mathematics coaches during planning and debriefing conversations. Such research can help mathematics coaches and those who supervise and train them to better understand the ways in which they incorporate these moves in an attempt to produce productive conversations around mathematical tasks of teaching.

There are instances where studies on coaching seem to align with the coaching practices recommended by the professional literature as providing indicators of success, however, most do not model *how* these practices look and sound when done well. In particular, there is a growing body of professional literature for mathematics coaches to utilize as resources (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013; West & Cameron, 2013). Despite this, it is challenging to find actual empirical data to support and see firsthand what effective mathematics coaching looks like in practice. More studies are needed to better understand why it is that sometimes coaching moves are effective, yet other times these moves are less effective according to the research. My study seeks to develop a more detailed understanding of the ways in which coaches phrase questions and offer ideas around mathematical tasks of teaching, and how they follow up these questions and suggestions based on the responsiveness of teachers, in an effort to support current mathematics coaches and future professional development for these teacher leaders.

Contextual Factors Related to Coaching

Much of the current literature on coaching has examined what it looks like to design and implement coaching initiatives effectively (Antsy & Clarke, 2010; Campbell & Malkus, 2011; Mudzimiri, Burroughs, Luedbeck, Sutton, & Yopp, 2014). This research has tended to focus on the training and practice of the coach, but often without providing descriptive evidence to illustrate this practice in detail. It has provided big picture evidence that coaches who are trained in the implementation of "effective coaching practices" can influence teacher practice in ways that orient teachers toward reform-based teaching, yet the research has not offered specific examples of how coaches do this more and less effectively. Understanding the decisions that coaches make in their conversations with classroom teachers and the extent to which coaching moves play out more or less productively in various situations is not a simple matter. There is more to understanding the influence of a coach on teacher practice than simply looking at their training or examining in isolation the planning and debriefing conversations that they have with classroom teachers. Identifying the extent to which coaching moves play out more or less productively is one piece of the puzzle. Recognizing the conditions and educational cultures that teachers and coaches work in and how those factors can influence teacher beliefs and instructional practices, as well as the beliefs and practices of coaches, are also worth considering (Goldsmith & Shifter, 1997). This study also seeks to understand the potential contextual factors that influence coaching practice specifically during the three part coaching cycle with classroom teachers.

Defining and Understanding "Context" as it Relates to Coaching

One of the challenges in understanding how contextual factors can affect coaching is the nature of the phrase "contextual factor" itself. Contextual factors have been defined in a variety of ways throughout educational research over the years (Dalal, 2013; Pintrich, Marx, & Boyle, 1993; Strom, 2015). Oftentimes, studies on teaching and coaching have described contextual factors differently based on the focus of the research design and questions of a given study. Part of the challenge in clearly defining these factors also stems from the fact that they can occur at a range of levels, from macro-levels like state and districtwide mandates, to micro-level factors such as a teacher's beliefs and experiences (Smith, Hayes, & Lyons, 2016). At a broad level, Merriam-Webster Online (n.d.) defined context as, "the interrelated conditions in which something exists or occurs." In my study, the focus is on the types of contextual factors that stand to directly influence the conversations between coaches and teachers during the three part coaching cycle. In the following sections, I examine the current research on what is known about contextual factors related to instructional coaching.

Smith, Hayes, and Lyons (2016) utilized an ecological framework to explain how the interaction of contextual factors at a range of levels can influence the roles of instructional leaders. Figure 2 illustrates the levels suggested by this framework, beginning with the individual and their "microsystems."

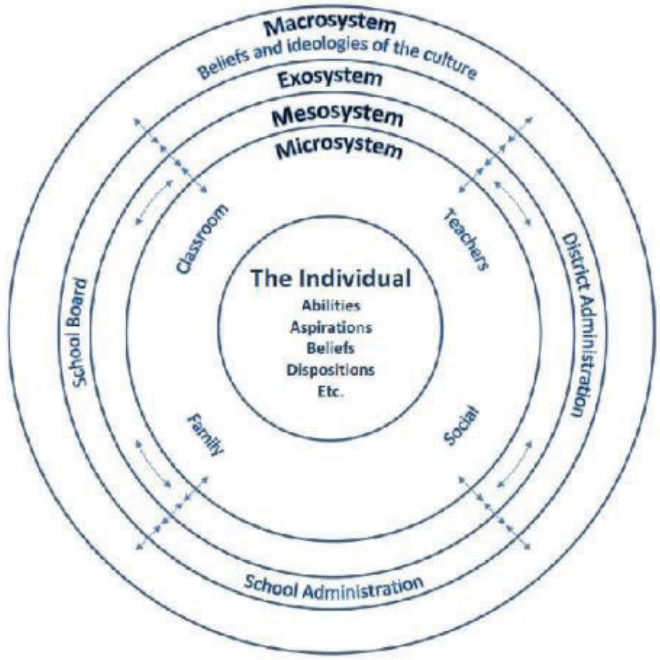

Figure 2. Relationships among levels of the ecosystem (Smith, Hayes, Lyons, 2016).

Although their study examined "instructional leaders" in a broader sense, in my study I will focus on mathematics coaches as instructional leaders. At the "microsystem" level, factors such as the training and beliefs of the teacher and/or coach can influence how they interact with the curriculum, students, and one another during the coaching cycle. The next level of "mesosystem" is comprised of these interactions, if any exist, between the various microsystems of the individual. The levels of "exosystem" and "macrosystem" exist outside of the direct interactions of the coach and teacher, including interactions with district policies and administration at the exo-level, and overarching educational beliefs and ideologies of the national and global educational systems at the macro-level.

Although Smith, Hayes, and Lyon (2016) provided examples of contextual factors that came into play at each of these levels in their case study, their list was by no means comprehensive. There is little other literature on the sorts of contextual factors that influence mathematics coaching at these micro- and meso- levels. Studies that have examined contextual factors varied in both the descriptions of and systemic levels of factors that they addressed (Pintrich, Marx, & Boyle, 1993; Smith, 2012), and little of the other literature on coaching has used this framework to examine contextual factors. Examining the existing literature on contextual factors related to coaching will clarify the role of the current study in adding to the knowledge base of how contextual factors can influence coaching conversations with classroom teachers.

Microsystems and Mesosystems as Contextual Factors

Of the coaching studies that have examined contextual factors, most described the relationship between the coach and classroom teacher as a major influence on the productivity of coaching initiatives. In their study of science coaches, Anderson, Feldman and Minstrell (2014) found that the ability for coaches to have deep, content focused work with teachers depended on relational trust, role synchrony (the ability of both parties to adjust their actions to the other's expectations), and a tendency to place coaches on a "teacher-administrator continuum." The researchers explained that these issues must be addressed continually and renegotiated in existing coaching relationships, not only in new ones, in order to continue deep coaching practice. Mudzimiri, Burroughs, Sutton, and Yopp (2014) also described factors related to the dynamics of teacher/coach relationships in the coaching cycles observed in their study. They identified various forms of coach-teacher communication, the substances of such communications, the stance adopted by the coach during these interactions (active, passive, collaborative, or directive), and the impact of the relational balance of coach-teacher communication as influential factors. Neither of these studies detailed what it looks like when these factors were present, specifically during coaching conversations with classroom teachers, or whether the coaches were able to negotiate these factors in ways that still led to productive coaching when they were present.

Such findings are compelling in terms of the role that contextual factors can have in influencing the relationship ("mesosystem") between a coach and classroom teacher. There has been little follow up to support or disprove the evidence from these studies to date, particularly not at the level of examining these and potential other contextual factors that influence the productivity of deep coaching conversations. The interplay between microsystems and mesosystems has the potential to help coaches and those who support them better understand how to negotiate contextual factors in ways that allow productive coaching to persevere. Understanding the range of these contextual factors, from the individual beliefs of teachers and coaches and how these influence the coaching relationship to factors from other relationships and outside influences, is a key contribution that is needed in the current literature that my study seeks to address.

Teacher beliefs as microsystems. In considering contextual factors around coach/teacher relationships, much of the professional literature (Knight, 2007; West, 2008) has suggested that coaches must meet teachers where they are in their current understanding of what it means to collaborate with a coach. Both the professional and research-based literature is sparse however, in examining what it looked like when coaches engaged in deep coaching with teachers who were not as open to or familiar with the process (Kise, 2006), or which coaching moves were utilized to support these teachers. Yopp et al. (2011) explained that effective "consumers of coaching" ask for targeted feedback, are active participants who are open to reflecting on their practice, are willing to express their needs and goals to the coach, and attempt to examine their own teaching practices. One area the literature has not deeply examined is whether there are aspects of being a coaching consumer that some teachers are unaware of when they work with coaches and how that influences coaching conversations. It is important to consider the ways this lack of knowledge could potentially interfere with teachers' participation in deep coaching cycles around mathematics. It is equally unaddressed in the literature what, if anything, coaches do to attempt to negotiate this in their planning and debriefing conversations with teachers.

In her book on promoting "differentiated coaching" for diverse groups of adult learners, Kise (2006) described a series of factors that could inhibit teachers from collaborating deeply with instructional coaches. Such factors included a fear or negative view of sharing in meaningful ways, teachers viewing themselves as experts who were not to be critiqued, teachers who were unwilling to share the perceived struggles they faced, and the intensifying of the work of teaching that came along with coaching. Kise suggested that some of these disconnects may have stemmed from ineffective beliefs, habits, and mental models about teaching. Kise, along with Cantrell and Hughes (2008) described the importance of fostering teacher efficacy in order to help teachers implement reform-based practices into their instruction. Coaches must attempt to negotiate teacher beliefs that do not always align with their own when forging a mesosystem. Although studies have examined this at a broader level, there is much to be further understood about how coaches go about addressing such issues during deep coaching conversations.

One role of the coach then, is to identify these beliefs, attempt to incorporate the strengths of the teacher in their collaborative conversations, and to provide evidence for teachers as to why alternative beliefs may be more productive to assume. Understanding what it looks like for mathematics coaches to do this is an underrepresented part of the existing literature, perhaps in part because reluctant teachers are not always the ones participating in studies of mathematics (or other content-based) coaching. Determining the effectiveness of such coaching conversations with classroom teachers is beyond the scope of this study. While not a major focus of my study, the teachers being coached in my research do vary in their willingness to accept support and ideas from a coach. My study can offer some evidence of coaches trying to enact productive coaching with reluctant teachers or teachers who are unfamiliar with coaching in order to better understand how coaches negotiate mesosystems with such teachers as a result.

Coaches' beliefs as microsystems. Teachers are not the only ones whose beliefs may act as contextual factors during the coaching cycle. It is also possible that there are times when coaches' underlying beliefs and perceptions about certain teachers may affect the ways in which they interact with said individuals. Antsy and Clarke stated, "It is the coach's beliefs and subsequent behaviours that influence decisions in relation to the strategies they promote with the teachers to influence change in their practice" (2010, p. 11). Although the authors did not originally intend this statement in the context of coaches changing their behaviors for how they interact with different teachers during coaching conversations, it is possible that this could occur. The knowledge and perceived interpretations of who teachers are and how they view teaching and learning mathematics may influence the ways in which coaches interact with them. Little to no empirical evidence exists to illustrate whether or not coaches enact coaching moves differently based on their perceptions of various teachers, or how they decide when to focus on the goals of the teacher or to promote their own agendas during coaching conversations. Understanding how the microsystem of the coach could potentially influence their mesosystems with certain classroom teachers is a needed addition to the existing research. It is beyond the scope of my current study to examine the microsystems of coaches at this time.

Ippolito (2010) found that coaches often had to negotiate the conversations that occurred during deep coaching cycles in ways that balanced being responsive to the needs and wants of the teacher and directive in ways that promoted district initiatives and research based practices. Similarly, Coburn and Woulfin (2012) described coaches as "…playing a key role in influencing teachers' variable responses" (p. 13) to new literacy initiatives. Coaches attempted to help teachers understand and implement new strategies by enacting the role of curriculum specialist. The authors of both studies found that coaches used a variety of strategies, such as pressuring teachers, persuading, and helping teachers to see connections between current and new strategies even when such strategies were somewhat different on the surface. At times, coaches even acted as buffers between teachers and a new initiative, encouraging them to implement certain features symbolically or superficially, rather than completely changing current practices. Coaches attempted to negotiate the microsystems of the classroom teachers and how teachers interacted with various mesosystems and exosystems in these studies in ways that maintained a functioning relationship between teacher and coach. Understanding how such moves translate to mathematics instructional coaching could be an important feature to consider in order to better understand how mathematics coaches negotiate these tensions in their conversations with teachers. Although my study examines the presence of these mesosystemic and exosystemic factors, it is beyond my analysis to fully determine the extent to which coaching moves may have mitigated some of these factors.

Contextual factors from multiple levels of the ecological system. In a few studies (Nicol & Crespo, 2006; Remillard & Bryans, 2004; Smith, 2012), contextual factors from different levels of this educational ecological system came into play. Smith (2012) found that curriculum materials and textbooks, school structures, training, and administrative and community influences affected the ways in which teachers enacted mathematics instruction. Despite receiving professional development from a program designed to move teachers toward a sense-making and connected approach to teaching math, these varied levels of factors led to a range of reactions to the initiative in practice. Another study similarly found that even when teachers utilized the same curriculum materials, teachers' experiences engaging with these materials were very diverse (Remillard & Bryans, 2004). Nicol and Crespo (2006) found that contexts such as the classroom environment and understanding of the curriculum had strong influences on how teachers went about enacting the curriculum.

Such studies suggest that teachers' orientations toward the materials they are using can influence the ways in which they enact mathematics instruction, whether negatively or positively. The classroom environment can also influence a teacher's beliefs around and enactment of the curriculum. In schools where contextual factors work in favor of teachers' incorporation of reform-based teaching, studies have uncovered a shared sense of purpose, coordinated effort, collaborative professional learning, and collective control as key factors that promoted such practices (Secada & Adajian, 1997). Although these studies were not connected to coaching initiatives, they raise questions as to how these kinds of contextual factors can influence coaching as a form of professional development intended to promote reform-based mathematics teaching. What is it that coaches do to try to develop feelings of having a “coordinated effort” or “collaborative” control during coaching conversations that could positively influence these conversations with teachers? It also raises questions around the role that the mesosystems between classroom teachers and their peers can play in influencing teacher beliefs and practices as well.

Additional research needs to be done to better understand how coaches attempt to negotiate factors, such as district and state initiatives, curriculum materials and their use, as well as the social interactions among teachers as they enact the three-part coaching cycle. My study does examine the extent to which coaches attempted to remain responsive (Ippolito, 2010) to teachers’ ideas through their use of particular coaching moves during the three part cycle, and attempts to identify instances where the microsystems of teachers may have influenced their mesosystem and work with the coach during reflective coaching conversations. It is beyond the scope of the current study to address the broader levels of the educational ecological system as it relates to coaching, meaning additional future studies would need to be conducted to further examine the exosystemic and mesosystemic levels of Smith, Hayes, and Lyons’ (2016) framework.

Temporal factors and coaching. Although Smith, Hayes, and Lyons (2016) discussed the issue of time as being prevalent throughout their study, they did not categorize it within any one ecological level in their framework. This is perhaps because issues of time can occur for a variety of reasons, including temporal issues that are imposed by district or school systems, as well as ones that occur due to the individuals involved directly in the coaching interactions. Much like teaching, the constraint of time is a prevalent issue that arises in discussion of the problematic nature of enacting the coaching process. Feeney Johnson (2008) posed several possible solutions to "finding time" for mentors to work with novice teachers, including holding informal discussions, scheduling formal discussions in advance, communicating small issues via email or phone, and setting priorities for collaboration. Although many of these suggestions translate to the role of the coach as well, coaches must negotiate both their own and the classroom teacher's time constraints. In instances where coaches hold multi-site jobs or have only partial release from teaching responsibilities, it can be challenging to set up common and consistent times to collaborate.

Even when common times are available, coaches must be flexible in negotiating planning and debriefing conversations with teachers. Bay-Williams et al. (2014) suggested that coaching cycles are both dynamic and contextual in nature. Dynamic in that "…you can begin at any phase of the coaching cycle," and contextual in that "…the implementation of the coaching cycle will be influenced by many factors, such as the teacher and coach's relationship as well as their beliefs about teaching and learning…" (p.6-7). Some of the literature states that ideally all coaching cycles would involve the three main parts: pre-planning, observing and interacting during the lesson, and debriefing after instruction. Ensuring this happens with all teachers and all coaching practice can present itself as a challenge at times. A variety of factors can influence the ability of the coach and teacher to set aside time for both planning and debriefing, and to ensure that this time is focused and uninterrupted in nature. If it is the reality of coaching that the three part cycle may not always occur, it is imperative to better understand how coaches attempt to negotiate these temporal factors in order to still have productive conversations with teachers around mathematical tasks of teaching.

In some studies, inclusion of all three parts of the coaching cycle was built into the framework of the research design (Hsieh, Hemmeter, McCollum, & Ostrosky, 2009; Huguet, Marsh, & Farrell, 2014; Kretlow, Cooke, & Wood, 2012; Mudzimiri, Burroughs, Luedbeck, Sutton, & Yopp, 2014). Oftentimes these studies claimed improvements in teaching practice as time was spent engaging in this deep planning cycle with a coach. It is also worthwhile to understand what happens in instances when all parts of the coaching cycle did not occur with fidelity. Matsumura et al. (2010) found that despite the intent of the study for literacy coaches to engage teachers in all three parts of the coaching cycle, the participation in full coaching cycles was much lower than anticipated. When coaches did engage in debriefing conversations, they were typically only around five minutes in length. The researchers cited competition between participating in coaching and the other "professional obligations" of the classroom teachers as a major factor that influenced the participation rate in this sort of deeper coaching conversation. The study did not examine the extent to which these conversations centered on meaningful discussion of mathematical tasks of teaching despite the brevity of the meetings.

In their study of literacy coaches, Bean et al. (2010) found that only approximately half of the coaching cycles involved observations of the actual lesson, and only four of twenty instances included a debriefing session. Their study failed to examine the potential contextual factors that may have led to this lack of time spent planning and debriefing the lessons. Although Ross (1992) found positive correlations between student achievement, teacher efficacy, and self-reported collaborating with an instructional coach, it was noted that coaches very rarely engaged in full three part coaching cycles that included an observation of the lesson. Such studies indicated that despite the entire three part cycle not taking place, that coaching was productive. It is worth examining further what it looks like for coaching to be productive within the individual parts of the three-part cycle with more detail. Little to none of the current research examines whether the planning or debriefing sessions can stand alone as productive conversations that promote reflection and analysis of teacher practice. If finding time to meet with teachers both before and after lessons to plan and debrief is challenging for instructional coaches, then developing a deeper understanding of what makes these individual conversations play out more or less productively could be an important contribution to the literature. My study examines the ways in which temporal factors did and did not influence the productivity of reflective coaching conversations with classroom teachers.

Mudzimiri, Burroughs, Sutton, and Yopp (2014) found that most coaching practice took place in classrooms, but other spaces such as offices, meeting rooms, hallways, etc. were often utilized during planning and debriefing sessions. Meetings occurred both formally and informally, and at a variety of times throughout the day, however in their study no coaching took place outside of duty hours. There is perhaps need for further understanding of how coaches negotiate working with teachers' schedules in ways that both honor the time of the teacher but maximize their ability to think deeply and critically about teaching mathematics, as well as what coaches do when the locations and times afforded to do so are prone to interruptions. Studies such as the ones presented here identify factors relating to time as having the potential to influence coaching conversations in a variety of ways. It can be difficult for coaches and teachers to find time to enact all three parts of the coaching cycle, and even when these conversations are scheduled, they can be very brief in nature. This makes it critical to better understand how coaches attempt to maximize the time they have with classroom teachers around mathematical tasks of teaching during coaching conversations. Additional information is needed to understand how coaches attempt to overcome the temporal challenges they face and still promote deeply reflective conversations within the constraints in which they work. My study looks to examine such factors as they interact with the coaching cycle at the micro- and mesosystem level of interaction between coaches and teachers in order to begin to fill this gap in the current research.

A Missing link on Contextual Factors and Coaching

Perhaps due in part to the various ways in which contextual features can be defined as they relate to coaching, there is still much to be learned in terms of how such factors influence the productivity of coaching initiatives. One element of particular importance that the current literature has not yet adequately addressed is how these factors influence the productivity of coaching moves within planning and debriefing conversations specifically. It is also unclear whether or not the current research has identified all of the contextual factors that can potentially interact with coaching practice at this level. The professional literature used by coaches as resources and toolkits (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013) does not examine how coaches can engage productively wither teachers despite the presence or absence of such factors. Looking at the ways coaches work with teachers in reaction to the tensions caused by contextual factors may help to identify discrepancies in how coaching moves play out with different classroom teachers.

Gaining a sense of how these factors act on coaches and teachers as they attempt to co-create new meaning and understandings about teaching mathematics may help coaches better understand how to negotiate such factors in future coaching practice. Although it is of interest to examine the presence and absence of contextual factors that influence the mesosystems that affect coaches and their collaboration with teachers, the more important focus for this study is developing an understanding as to how coaches utilize and interact with these features in practice. My study seeks to identify the contextual factors that are present within coaching cycles across my data, as well as developing a better understanding as to the interplay between these factors and the productivity of coaching moves in helping teachers attend to and incorporate a range of mathematical tasks of teaching in their practice.

Chapter Three

Methodology

The purpose of this qualitative study was to better understand the ways in which elementary mathematics coaches interacted with classroom teachers during coaching conversations in order to promote teacher reflection on mathematical tasks of teaching. My interest in this study developed over time as I sought to improve my own work as an elementary mathematics coach for the large urban district in which I work. Coaching is a newer position in the district, and as I began to learn how to negotiate this role, I sought ways to implement and share with my peers the ideas and knowledge I developed through my participation in Math in the Middle, a professional development program funded by the National Science Foundation. At the time of the study, I was in my fourth year as a math coach, and the role had evolved since its inception from providing resources to teachers and offering schoolwide professional development, toward the deeper, reflective conversations of the three part coaching cycle. This background knowledge and experience situated me as a researcher with unique expertise for my study, both with emic knowledge as a mathematics coach within the same district as the participants, having had the same coaching training and experience with district resources, as well as the etic perspective of a researcher observing the process of the productivity of these coaching conversations from the outside.

As part of work that was situated within a larger grant funded by The Sherwood and Lozier Foundations, I designed a study of the practices of six of my colleagues and fellow mathematics coaches in the district as they planned and worked alongside classroom teachers over five months. My goal was to better understand the coaches' work with teachers during the three part coaching cycle, particularly the conversations that occurred in planning for and debriefing about mathematics lessons. I observed the coaches during the enactment of the three part coaching cycle with a range of classroom teachers. I engaged with coaches in one on one interviews about their work with these teachers, and interviewed several of the teacher participants at the end of my data collection as well. My goal was to develop a deeper understanding of the moves that coaches made to foster conversations around the mathematical tasks of teaching, and to determine the types of contextual factors that were present during these conversations. In order to do so, I determined that a qualitative research design offered the best option to examine the types and frequencies of coaching moves used during coaching conversations to foster talk around the mathematical tasks of teaching compared to the types of coaching moves suggested by the professional literature (Campbell, Ellington, Haver, & Inge, 2013).

Why Qualitative Design?

Much as teaching is a complex activity, the work of an instructional coach in helping teachers deeply examine and refine their practice is an equally intricate practice to study. Coaches must make decisions about how to guide the reflective conversations and planning with classroom teachers, including when to push teachers to consider reform-based practices at the goal of coaching and when to be responsive to the goals of the teacher (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Ippolito, 2010). The use of qualitative design to examine coaching moves during the three part coaching cycle allowed for a detailed investigation of one facet of the role of mathematics coaches as a classroom supporter (Killion, 2008): the enactment of coaching moves during the reflective conversations that occur as part of the three part coaching cycle. Figure 3 illustrates the three part coaching cycle as it is typically enacted in the professional literature on coaching.

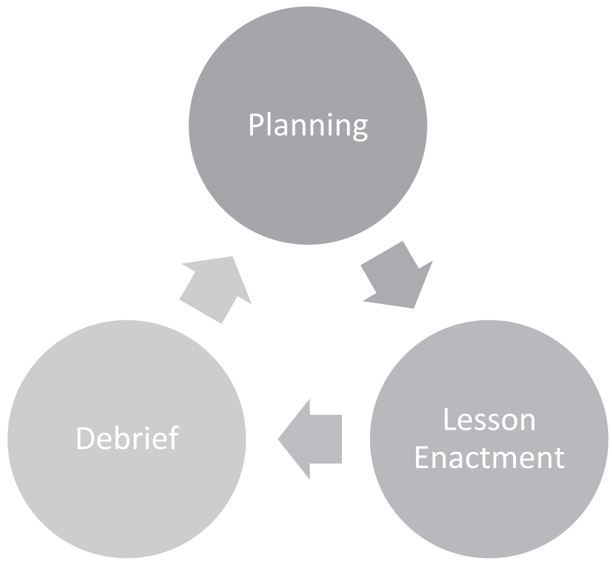

Figure 3. Model of the three part coaching cycle. Adapted from *Mathematics coaching: Resources and tools for coaches and leaders, K-12* (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014).

For the purpose of finding opportunities in this three part cycle within which to best examine coaching moves, I narrowed my analysis to the planning and debriefing conversations between coaches and teachers. It was within these two parts of the cycle that direct interactions between the coach and teacher most often took place, which afforded me the greatest opportunity to examine coaching moves as they were enacted in their natural setting.

This study adopted a constructivist-interpretivist paradigm (Denzin & Lincoln, 2011), in which the researcher uses inductive reasoning and "thick description" to describe and interpret the lived experiences of the participants (Hatch, 2002; Neuman W., 2014). According to a constructivist-interpretivist theory, the goal is to study "meaningful social action" in order to understand these actions in their natural setting, how they are constructed and interpreted by the participants, and examine the contexts within which these actions take place (Neuman, 2014, p. 104). In my study, the goal was to deeply understand reflective coaching conversations between math coaches and teachers, in order to develop an interpretation of what it meant to use coaching moves in ways that were more and less productive in helping teachers consider a range of mathematical teaching tasks. In doing so, I also sought to understand the contexts that interacted with these conversations as they took place, in order to better understand the sorts of factors that stood to influence this coaching work. Neuman described these contextual factors as being "wedded" to the concepts and generalizations of the data. This means that examining this sort of work assumes the stance that "…social interaction cannot be isolated from the context in which it occurs…" (p. 108). Hatch (2002) described the importance of researchers in the constructivist-interpretivist paradigm as working to co-construct an understanding of the studied phenomenon. With this is mind, it is an expectation for the researcher to be actively engaged in participation, rather than remaining completely detached from the participants throughout the study. As a colleague and fellow mathematics coach to the participants in my study, such a stance as a researcher was logical to take. The coaches in the study viewed me as a trusted colleague, with whom they could ask questions and discuss coaching situations, even as I acted as an outside observer of their work.

Conducting a study from a constructivist-interpretivist stance requires the researcher to embed themselves within the naturalistic setting where the object of the research takes place. For my study, I conducted interviews and observations in the offices and classrooms where coaches and teachers normally interacted to provide a range of data that fully represented the perspectives both of the instructional coaches and, to the extent possible, the classroom teachers with whom they worked. Interviews, observations, and field notes were collected with the intent of not only developing a rich description of the interactions between teachers and coaches, but also to help me triangulate my findings in ways that increased the validity of my research (Yin, 2008). As an experienced mathematics coach, I had knowledge specific to coaching that focused my observations and note taking on aspects of the coaching conversation that were important to my data analysis. To mitigate any potential blind spots this may have caused, I also had to use an etic perspective to maintain an objective lens throughout data collection. Collecting these sorts of data allowed me to maintain a focus on using a combination of inductive and deductive reasoning to gain a more comprehensive view of how coaching moves played out in different conversations (Bogdan & Bilkan, 2007; Creswell, 2013).

According to Merriam (2009), "Qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences" (p. 5). The inductive and interpretive nature of qualitative design, as well as the focus on the human experience, makes this methodology both a situational and personalistic form of research, which was well suited for a study of social interactions and teacher learning (Creswell, 2013). It was these interactions that were the focus of my analysis. In this study, I was not concerned about particular coaches, so much as what coaches in general did, and the coaches selected to participate in the study helped me better understand coaching conversations and connect them back to the existing literature (Stake, 1995). Studying the role of a coach as a classroom supporter during the three part coaching cycle, as illustrated in Figure 3, allowed me to focus an analytical lens on the deep conversations that coaches have with classroom teachers as a way to develop an in depth understanding of how coaching moves did and did not engage teachers in reflection on mathematical tasks of teaching.

The National Science Foundation (2013) described foundational research methods as those that contribute "…to core knowledge in education" (p. 9), which encompasses developing an understanding of various components of both teaching and learning. In foundational research, the goal is to deepen the educational knowledge around which theories of practice can be developed. Such descriptions aligned with my research goals of refining the current understanding of what productive coaching moves look like in helping teachers to develop attentiveness and responsiveness to a range of mathematical tasks of teaching in their practice. Doing so helped contribute new knowledge to the field that could influence the further development of professional development and supports for mathematics coaches in the future. By maintaining a constructivist-interpretivist paradigm, this foundational research study sought to understand the object of study (coaching conversations) without making direct connections to educational effects or outcomes. Although this study looked to better understand the productivity of coaching moves in various coaching conversations with classroom teachers, it was not the intention to evaluate or look for causality in my study. The intent of this study was to extend the body of knowledge on what constitutes productive mathematics coaching moves, as well as to highlight the potential contextual factors that stand to influence coaching conversations, in order to advance the policy and practices designed to support mathematics coaching programs.

In my study, I sought to examine coaching conversations as a clearly defined platform, where learning about the moves of the coach and resulting actions of the teacher could help to inform what it is about coaching moves that do and do not help teachers consider mathematical tasks of teaching productively. Using the three part cycle to study these coaching moves was especially necessary since the variables (in this study the range of coaching moves) are often so complexly embedded that they are not possible to identify ahead of the study. These variables can be potentially important to understanding the phenomenon, especially with educational innovations such as coaching, in ways that help researchers develop structures for further studies and future research. Studying multiple coaches at various schools and working with a variety of classroom teachers in different settings allowed me to study coaching moves from multiple perspectives and better understand the factors that may have influenced the conversations between the coach and teacher (Creswell, 2013; Merriam, 2009).

Setting and Participants

For this study, the participants were six elementary mathematics coaches in a large, urban school district. As well as being experienced classroom teachers, these elementary mathematics coaches completed one of several graduate programs focused on mathematics prior to becoming a coach. The coaches also received additional professional development on coaching from both the school district and outside professional development programs. District training included multiple professional development sessions on the district's administrative coaching model, and external training was provided by The Examining Mathematics Project (2015) across a series of 8 full day sessions to support coaches' learning about the content focused coaching model (Saphier & West, 2009). The funding of the coaches and this study was supported by The Sherwood and Lozier Foundations. The six mathematics coaches served a total of eight elementary schools during the data collection period of the study. Two coaches served in dual site roles, the remaining four coaches in single site coaching roles during the 2014-2015 school year. Many of the schools that the coaches served were labeled as "low achieving" based on results of the statewide mathematics assessment, with three of the eight schools achieving at less than 50% proficiency on the 2014-2015 statewide assessment. Most of the schools served students of low socioeconomic status (SES) as well, with six of the eight schools having rates at 85% and above for students receiving free or reduced lunch (a common indicator for determining SES) during the year of the study.

A total of 22 complete coaching cycles were observed and recorded in these eight elementary schools, including work with 20 classroom teachers during the spring of 2015. Teachers ranged in experience from first year novices to twenty year veterans across the eight schools. The backgrounds of the coaches also had some variability. Table 2 shows the background information on each of the coaches who participated in the study.

Table 2

Background Information on Participants

Range of Teaching Experience		Range of Coaching Experience		Schools Served	
Number of Years	Number of Coaches	Number of Years	Number of Coaches	Number of Schools	Number of Coaches
5 – 10	1	1 – 2	5	1	4
11 – 15	3	2 – 3	0	2	2
16 – 20	1	3 - 4	1		
21 - 25	1				

Each of the mathematics coaches were experienced former classroom teachers within the district, with anywhere from 8 to 22 years teaching experience. Their experience as mathematics coaches ranged from approximately one and a half to three and a half years at the time of the study. From the coaching sample, four of the six coaches worked at single sites and two of the six coaches worked in dual school buildings (spending approximately two and a half days a week at each site). The range of teaching experience, as well as the fact that some coaches served multiple sites added another potential layer of contextual factors that came into play in scheduling and enacting coaching conversations that this study examined.

Research Plan

The major question guiding my research was: How do mathematics coaches craft the conversations they have with teachers during planned three part coaching cycles in the way that they do in order to promote teacher reflection and shifts in instructional practice? The conversations that occurred within the three part coaching cycle were chosen as a particularly prominent platform that coaches use to initiate deeper coaching conversations with teachers. I intentionally chose to focus on coaching conversations rather than particular coaches. This allowed me to maintain anonymity for the small participant pool in my study by reducing the need to tie coaching moves back to individual coaches during my analysis. Instead, I was able to remove identifying information from the transcripts and focus on the coaching moves themselves. This was critical both to maintain confidentiality for my participants and to ensure I maintained proper ethical boundaries in my research (Creswell, 2013), as well as the trust of individuals with whom I worked in the district.

The first sub-question that guided this research was: What are the questions, statements, and moves that coaches make to support teacher thinking and instructional planning? Campbell, et al. (2013) suggested that asking good questions is at the heart of the strategies that coaches employ in their work with teachers. Mathematics coaches question teachers about student learning and about reflecting on teacher practice, but also must know when to ask a question and when to wait for a better time, and must be comfortable posing questions that have no immediate answer. Additionally, coaches use other moves such as offering suggestions and sharing examples in order to help teachers think deeply about planning mathematics lessons that are centered on the mathematical tasks of teaching. Developing a better understanding of the types of moves coaches make, and how they shape reflective conversations with teachers about planning and teaching math, is critical to developing highly effective mathematics coaches. This research seeks to analyze what sorts of questions coaches pose, suggestions they offer, and examples coaches use during deep planning and reflection interactions with teachers to focus on mathematical tasks of teaching, and to what extent these moves appear to be successful in meeting the intended coaching goals.

The second sub-question of this study was: What are the contextual factors that influence the work of the coach with classroom teachers and how do such factors influence the moves that coaches make with classroom teachers? In order to fully understand why some coaching cycles with teachers were more effective than others at helping teachers attend to a range of mathematical tasks of teaching, it was also necessary to determine to what extent contextual factors may have influenced these conversations. I sought to analyze both the sorts of moves that coaches used that were less and more productive, as well as whether mitigating factors might have influenced these conversations.

Data Collection

Data was collected over a large sample of coaching cycles with the intent of helping me to better understand the complex work that coaches do with teachers and what they say and do during these interactions in order to help teachers plan and reflect around mathematical tasks of teaching. During the spring semester of 2015, I scheduled with the six coaches as often as possible on a weekly basis to maximize the number of coaching cycles observed. In all, I gathered evidence from 25 total coaching cycles in that time, 22 of which that included a face-to-face debrief. The observations of coaching conversations were audio taped and transcribed for later analysis. An observation protocol (Appendix B) was utilized to focus my note taking on the things the coach said and did during the coaching cycle to meet coaching goals, promote reflection *in* action (Schon, 1983), and to promote a focus on mathematical tasks of teaching.

I also maintained field notes throughout the observation of the coaching cycles to better capture a complete view of the planning and debriefing conversations between coaches and teachers by including data, for example, that the audio-recordings could not capture. I kept notes of the classroom environment, mathematics and ideas that were shared in writing (both during the planning and debriefing and during the lessons), and notes about non-verbal communications that occurred during the cycles. These observations of coaching cycles were supported by brief follow-up interviews with the coaches (Appendix C) that clarified background information about the teacher, previous coaching work, and their goals for the coaching cycle. Using a range of data sources provided multiple ways for me to better understand the contexts present during each coaching cycle, as well as the types of interactions that occurred between teachers and coaches during each part of the cycle.

Collecting multiple forms of data during these sessions allowed for analysis of what coaches said to teachers, how they responded to teacher remarks, and how they focused reflective conversations with teachers in ways that maintained or deviated from the intended goals of the cycle around mathematical tasks of teaching. Of particular interest were the "moves" that coaches made during these sessions to be responsive, directive, or create a balance between the two in order to impact instructional practice in ways that meet the diverse needs of student learners of mathematics (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Ippolito, 2010). Conducting follow-up interviews offered participants' insights into various facets of the issues coaches may have faced in their work with different teachers. Observations allowed me to consider factors that arose during the coaching cycles that perhaps participants did not self-report. To be able to successfully conduct interviews of the participants, Creswell (2013) described the need for the researcher to develop an "interpretive lens" (p. 51), and to ask open-ended questions that allow them to collect a variety of data that allows for rich description (Stake, 1995). Therefore, I developed a series of semi-structured questions to focus the interviews throughout data collection, as well as near the conclusion of data collection.

I adapted several instruments for data collection during my initial and follow up interviews with coaches from the Examining Mathematics Coaching (EMC) project through Montana State University. It was a five-year longitudinal study, the results of which yielded definitions of the roles of mathematics coaches and the domains and depths of knowledge needed for coaching (Mudzimiri, Burroughs, Luedbeck, Sutton, & Yopp, 2014; Sutton, Burroughs, & Yopp, 2011). EMC developed a series of surveys and questionnaires for their own coaching studies, which are available for use by other educators and researchers at the project web page (http://www.math.montana.edu/~emc/Instruments.html). The EMC Coaching Skills Inventory and EMC Coach Reflection and Impact Survey included questions for mathematics coaches regarding the background and training that they received that made them well-suited to instructional coaching, as well as questions that helped me gain a better sense of the types of things coaches talked to classroom teachers about during the coaching cycle.

I adapted the first instrument from a survey to develop information seeking questions that were more open-ended for the brief pre- and post-observation interviews of coaches that I conducted before and after observations of coaching cycles (Appendix C) to develop an understanding of how coaches were participating in deep, instructional coaching around mathematical tasks of teaching. I also adapted portions of the Reflection and Impact survey into questions for the mathematics coach to consider during their exit interviews with me at the end of the semester (Appendix D). Finally, I developed an interview protocol similar to the brief interview questions for coaches in order to gain the perspective of several teachers near the end of the data collection period (Appendix E).

I engaged in these brief pre-observation and post-observation interactions with the instructional coaches, using the pre-observation interview to ascertain from the coach's perspective what their intentions were for the work of the day. The open-ended questions allowed me to gather additional information from coaches about their work with particular teachers in order to better understand the contexts within which particular coaching cycles were enacted. These brief interviews were audio-recorded and transcribed, as they had the potential to provide pertinent information outside of the bounds of the formal coaching cycle itself to inform this study. I was unable to observe cycles where the mathematical content was similar across coaching cycles, however many of the observed cycles focused around similar issues related to the pedagogical moves around teaching elementary mathematics. For example, several cycles centered around incorporating math talk and "talk moves" into the lesson (Chapin, O'Connor, & Anderson, 2013). Having similar topics related to teaching practices and strategies across multiple data sources allowed me to focus on how coaching moves and the context within which the coach attempted to enact these moves influenced conversations with classroom teachers.

The complete scope of my data collection is shown in Table 3, including the types of data collected as well as the quantity of each data type I was able to collect.

Table 3

Data Collection Spring 2015

Data Sources	Quantity of Data Collected
Observations of planning conversations	27
Observations of debrief conversations	22
Brief, informal conversations with coach	39
Researcher field notes on coaching cycles	25
Extended final coach interviews	6
Final teacher interviews	8

The use of multiple data sources allowed for triangulation of the data throughout my analysis. I conducted initial coding to look for relevant, over-arching themes and issues that arose around the types of coaching moves and teacher responses present in the planning and debriefs, before I refined these themes to conduct a second round of analysis. I triangulated my findings using multiple sources of information besides the three part coaching cycle, including the informal and formal interviews with coaches and a selected sample of the classroom teachers to increase my confidence in my results. Throughout the course of data collection and data analysis, I compared the transcripts from these interviews and planning conversations (what coaches actually said and did) with my field notes and evidence from coaching debriefs and follow up interviews (what coaches did and believe they did) to gain a better understanding of the complex nature of these interactions. This triangulation allowed me to take my analysis and compare it to the interpretation of the coach, and when possible the classroom teacher, of the events as they occurred. This helped me to identify the types of coaching moves used, how teachers responded by attending or not attending to mathematical tasks of teaching, and the contextual factors that were present in each coaching cycle across my data.

Analytic Frameworks for Examining Coaching Moves

In order to answer my two research sub-questions examining the types of coaching moves use, what sorts of contextual factors are present, and to determine the extent to which these two things contribute to more or less productive coaching conversations, I needed to develop tools to aid my analysis. In this section, I explain the rationale for and development of two analytical tools that I utilized to help me answer these questions.

A Tool for Analyzing Coaching Moves in Terms of Mathematical Tasks of Teaching

In Chapters 1 and 2, I referenced a study by Ball, Thames, and Phelps (2008) around *mathematical tasks of teaching* as a frame of reference for the sort of work that teachers do when planning and teaching mathematics in reform-oriented ways. As I highlighted throughout these first two chapters, there are parallels between the mathematical tasks of teaching and what NCTM (2014) regards as high leverage, research-based mathematics teaching practices. Framing the coaching moves suggested by the professional literature (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013) around these mathematical teaching tasks helped me better understand the types of questions and coaching moves that were potentially productive in moving teachers to attend to reform-oriented teaching practice in their planning and debriefing. After developing working descriptions of the tasks in Chapter 1 (see Appendix A), I coded the planning and debrief data for evidence of teachers working on these tasks, and looked for common activities and themes within the conversations between teachers and coaches that would be evidence of work on one or more of the tasks.

My next step was to consider how some of the mathematical tasks of teaching clustered around similar topics and purposes. Table 4 illustrates my categorization of the 16 mathematical tasks of teaching (MTT) around three overarching themes related to what I developed in the first round of my data analysis. As I coded and examined my data for tasks that teachers were working on, I noticed there were tasks that seemed focused on the design and set up of the task or problem (the mathematics) itself, as stated in the descriptions developed before coding. These teaching tasks included: presenting mathematical ideas, asking productive mathematics questions, and modifying tasks to be easier or harder. There were also tasks that, in the descriptions developed, focused on the mathematical goals of the lesson. These teaching tasks included: finding an example to make a specific mathematical point, linking representations to underlying ideas, appraising and adapting the mathematical content of textbooks, and selecting representations for a particular purpose. The third theme of mathematical teaching tasks focused around examining and anticipating student thinking. The tasks in this theme included: recognizing what is involved in using a particular representation, evaluating the plausibility of student claims, and giving or evaluating mathematical explanations.

Table 4

Developing Overall Themes around Mathematical Tasks of Teaching (MTT) for Analysis

Theme	MTT Aligned with Theme
Mathematical Goals	• finding an example to make a mathematical point • linking representations to underlying ideas/representations • appraising/adapting the content of textbooks
Mathematical Problem Design	• presenting mathematical ideas • posing productive questions • modifying tasks to be easier/harder
Students' Mathematical Thinking	• recognizing what is involved in using a representation • evaluating the plausibility of student claims • giving/evaluating mathematical explanations
Other	• connecting topics to future/prior years • explaining mathematical goals to parents • choosing/developing usable definitions • using/critiquing mathematical notation • responding to students' "why" questions • selecting representations for a particular purpose • inspecting equivalencies

In Chapter 1, I organized these mathematical tasks of teaching similarly, but with different intent. My goal in Chapter 1 was to illustrate how the mathematical tasks of teaching connect to the research-based teaching practices suggested by the literature, and to offer examples of what these practices look like. Here, my goal was to organize the coding and analysis of my data into overarching categories so that I could better understand emerging trends that developed during my first round of analysis.

These themes in Table 4 did not address all sixteen of the mathematical teaching tasks. There were certain tasks that did not particularly fit into these themes, as well as ones that did not come up in my data, including: connecting a topic being taught to topics from prior or future years, explaining mathematical goals and purposes to parents, choosing and developing useable definitions, and using mathematical notation and language and critiquing its use. These were also tasks for which I had limited or no examples of in my current data set, such as “responding to students’ why questions.” Similarly, although “selecting representations for particular purposes” and “inspecting equivalencies” might be argued to belong in one of the themes, there was not enough evidence of this task in my data to examine it further in the scope of the current study. Due to this limited evidence, I chose to place these tasks in the category of “other,” and though they may occur during coaching and may provide additional insights into the work of coaches, this study does not include them in the analysis.

A Tool for Analyzing Contextual Factors based on an Ecological Framework

The second research sub-question for my study sought to better understand the types and influence of contextual factors on this deeper coaching work of the three-part cycle. In Chapter 2 I discussed a study on the ecological systems of instructional leaders. This research provided the basis for the development of an analytical tool to examine the contextual factors present during coaching conversations in my study (Smith, Hayes, & Lyons, 2016). I adapted this framework using the categories: 1) influences from microsystems, 2) influences from mesosytems, 3) temporal influences, and 4) other. Although temporal factors were outside of any particular system in the framework presented in the original study, the researchers did cite its relevance, and it was one of the most prevalent factors presented by the literature in Chapter 2, thus it seemed worthwhile to include as a category for coding. I also recognize that it is possible for contextual factors that do not fit into one of the other three categories to occur in the data, and so I included a category of "other" to capture any outlying factors should they present themselves. As Table 5 illustrates, Smith, Hayes, and Lyons presented some examples of the types of factors that occurred within the microsystems and mesosystems in their study. It was my goal to use these ecosystemic levels as a starting point in my analysis of potential contextual factors as they arose in my data.

Table 5

Categories for Coding Contextual Factors and Examples of Each

Microsystem Factors	Mesosystem Factors	Temporal Factors	Other Factors
• grade level teachers • other faculty • administrators • social groups • classroom	• common membership between coach and microsystems of teachers • perceptions of mesosystem by coach	• finding time/ scheduling • brevity of time • interruptions	

For example, at the microsystem level, a classroom teacher's regular interactions with various other individuals may have influenced their beliefs in ways that impacted their work with the coach. Within the mesosystem, factors such as whether or not the coach worked with other teachers within a teacher's microsystem may have influenced this work as well. As I discussed in Chapter 2, within the bounds of the researchers' original case study it is likely that the list of potential factors they developed was not exhaustive. In my analysis of the data, it is possible that additional contextual factors arose as part of these two categories, and I intended to add to the existing list of factors if this came out during my analysis.

Methods of Data Analysis

As most of the discussion around mathematical tasks of teaching between the coach and classroom teacher took place during the planning and debriefing conversations in the coaching cycle, much of my analysis focused on these two components of my data. I analyzed the informal conversations I had with coaches prior to and sometimes after the coaching cycles, as well as the more formal end of semester interviews with coaches and teachers to offer additional insights from the participants as to some of the contextual factors that may have come into play. I coded instances of contextual factors that the coach shared were present or that I observed during the cycle, and compared the types and counts of contextual factors that were present in less and more productive coaching conversations to look for emerging trends. Much of my analysis relied on qualitative methods (Creswell, 2013; Merriam, 2009), trying to determine patterns and trends around the types of coaching moves that coaches used in their work with teachers. A minimal amount of quantitative analysis was also done in examining the planning and debrief transcripts in order to further understand the patterns and trends I saw emerging.

Planning and Debriefing Conversations

I audio recorded and transcribed all of the face to face planning and debriefing session between coaches and classroom teachers. In order to label and organize these conversations while maintaining anonymity for the study participants, I created a list of each planning session, organized by coach and in chronological order as to when they occurred during the data collection period. Thus, Coach One, who had three planning sessions with teachers, was classified as “Planning 1, Planning 2, Planning 3.” Coach Two’s planning sessions began with the label, “Planning 4” and numbering continued as such through all six coaches and the planning conversations until I reached the final planning session with Coach Six, which I labeled as “Planning 27.” I organized and labeled the debrief conversations in the same manner, meaning that Debrief 1 is the conversation with the same coach and teacher that followed Planning 1, and so forth. When a debrief did not occur, I skipped that number to maintain consistency in numbering the sessions between the same coach and teacher throughout.

In the first round of my analysis, it was important to consider in what ways the coach helped the classroom teacher consider a variety of mathematical tasks of teaching. Thus, I coded each of the transcripts for the planning and debriefing conversations for the various mathematical tasks of teaching that teachers discussed in these sessions. I conducted counts of the types of teaching tasks that occurred in each conversation, to determine the range of which sorts of teaching tasks were discussed in coaching cycles across the data. Additionally, I tallied the number of mathematical teaching tasks that were grouped within the three overarching themes of mathematical goals, mathematical problem design, and understanding students’ mathematical thinking. These latter two elements constituted part of the quantitative part of my analysis.

I also went back to these transcripts to code the coaching moves that were made that preceded the teacher talk around the different teaching tasks, when in fact such moves initiated talk around the tasks, to determine the types of moves coaches used to initiate talk around the three MTT themes in a second round of analysis. I used the work of Campbell et al. (2013) to broadly categorize the coaching moves around asking questions, sharing examples or suggestions, and examining students’ mathematical knowledge and thinking that occurred in my data, and then dual coded them as to the clusters of mathematical tasks of teaching (if any) to which these moves pertained. My goal was to determine whether the types or number of mathematical tasks of teaching the coaches and teachers discussed mattered, and to examine these coaching moves for patterns that may have led to more or less productive conversations around mathematics teaching. By examining coaching moves and sections of conversations, rather than focusing on entire planning and debriefing sessions, I was better able to maintain the anonymity of the coaches in the study throughout my analysis by eliminating some of the context of the coaching cycle afforded by examining complete transcripts.

Interviews

I audio recorded and transcribed semi-structured interviews before and after most of the coaching cycles that I observed in order to provide insights into the goals and thinking of the coach about their work with different classroom teachers. The brief, informal conversations I labelled as "conversation with coach" and included the number of coaching conversation that they tied to. For the formal interviews at the end of the semester, I only labeled transcripts with the date, so as to maintain the anonymity of the participants as much as possible. At times, these conversations offered evidence to support the possibility of contextual factors that came into play with the coaching work observed in the planning and debriefs. Additionally, I utilized information from both the six mathematics coaches and seven of the classroom teachers from longer, more formal interviews at the conclusion of my data collection in order to gain a sense of the perspectives of both parties with regard to the work that occurred during the coaching cycles and any work that may have occurred between cycles. These informal and formal interviews provided me with additional information to address my second research sub-question that looks to examine the possible contextual factors that potentially influence some of the work of coaches during the three part coaching cycle in round three of my data analysis.

Field Notes

Throughout all of my observations of the three part coaching cycle, as well as during one on one interviews with coaches and teachers, I took notes on the conversations that occurred. I attempted to capture shifts in conversation from talking about mathematical content to organizational and logistical issues, as well as talk about anticipating student thinking or analyzing student work. I made note of times when the teacher and coach "rehearsed the mathematics" or otherwise examined specific mathematical problems in planning, as well as examples of student work that the pair analyzed during their conversations before and after the coached lesson. I used my field notes as a source of information to support the transcripts from planning and debriefing sessions as they pertained to these topics throughout all rounds of my analysis.

It was my goal in my analysis to make as transparent as possible the moves that coaches made to help teachers examine a range of mathematical tasks of teaching in their work, in order to determine what it was about these moves and patterns within them that led to more and less productive conversations with teachers about the math. Table 6 offers the complete data analysis process I undertook to examine my research question and sub-questions.

Table 6

Steps and Purposes of Each Round of Data Analysis

Analysis Steps	Purpose
Round One: Coding and Counts of Instances Where Teachers Attend to MTT	
Analysis Steps	Purpose
Code planning/debriefs for teacher talk about MTT	Determine types of MTT teachers attend to
Conduct counts of MTT types in planning/ debriefs	Determine frequency/trends in MTT discussed
Conduct counts of MTT within 3 MTT themes	Determine frequency/trends in MTT themes discussed
Round Two: Coding of Coaching Moves that Initiated Teacher Talk around MTT	
Analysis Steps	Purpose
Code coaching moves that foster teacher talk about MTT	Determine types of coaching moves that led teachers to attend to MTT
Secondary coding of coaching moves linking them to MTT teachers attend to	Determine types of coaching moves led to teachers attending to MTT and MTT themes
Examine coded excerpts of coaching moves & teacher responses	Determine trends/emerging themes related to less and more productive coaching moves
Examine coach interviews and conversations, field notes	Verification of analysis findings
Round Three: Coding Data for Evidence of Contextual Factors	
Analysis Steps	Purpose
Code coach & teacher interviews, field notes, conversations for contextual factors	Determine types of contextual factors present across coaching conversations
Compare codes for contextual factors to analysis of the productivity of coaching moves & conversations	Determine trends/emerging themes between contextual factors & productive coaching moves

Limitations

Despite my efforts to collect a robust amount of data, findings from qualitative research are not typically intended to be generalizable. My study followed a limited number of mathematics coaches, within an approximate time frame of one semester for the purpose of examining the types of coaching moves employed by mathematics coaches in ways that more and less productively helped teachers to consider mathematical tasks of teaching in their practice. Determining trends that might unfold over an extended period of time or within a single coaching site then, were beyond the scope of this study. Since coaches self-enrolled in scheduling observations of coaching cycles with me, I had little to no control over which teachers they worked with during my observations. Some of the teachers who participated in the observed coaching cycles may have been pre-disposed to working with an instructional coach and it is possible that my results based on the work coaches did with these teachers was not representative of the work that the coaches did with other teachers in their buildings. There are certain teachers who may not have been asked or may not have chosen to participate in this study with their mathematics coach. Understanding how the moves that a mathematics coach makes when working with more reluctant teachers is perhaps beyond the scope of this study then as well. Another potential influence of this is that the subset of teachers who I was able to interview are most likely not representative of these more reluctant teachers as well.

Another challenge with my data collection was that due to the fluctuating schedules of coaches in different buildings with classroom teachers, it was rare for me to have the opportunity to observe a coach work with the same classroom teacher more than once. I was able to observe three instances of coaches working with the same teachers across the semester, only one of which where the cycles were scheduled closely together and focused on a continuous mathematical goal. As a result of these limitations in data collection, it is perhaps difficult to ascertain how some of these coaching moves played out beyond the observed portions of coaching cycles with a given classroom teacher. Additionally, there were times when these changing schedules led to coaching cycles being cancelled partway through (typically after the planning session) or the debrief being conducted via email instead of face to face. There were two coaching cycles that were canceled and unable to be rescheduled after the initial planning, and two coaching cycles where the debrief was done via email, leading to exchanges that were much briefer in nature.

Finally, in addition to limitations with data collection, it is difficult for the researcher to remain completely neutral in qualitative studies. In addition to my role as the main researcher in this study, I also worked alongside these coaches. Although this experience gave me insights into the work of mathematics coaches, as well as what this work looked like in the context of this particular school district that other researchers might not have, it also presented possible limitations to my study. In returning to my research question, I had to remember that my study was not about evaluating coaching, it was about understanding coaching moves. I had to maintain a focus on these moves, and make an effort to accurately report both less and more productive moves as they occurred across my data. In Chapter 4 I will discuss the continuum I developed to define productive coaching moves. Doing so allowed me to move beyond categorizing coaching moves only as “productive” or “unproductive,” and to present a range of productivity in my findings. I tried to remain rigorous, systematic, and consistent in my coding of the data, and as soon as it was possible, I disassociated coaches’ names from the recorded coaching events. The large amount of data I collected helped me to distance myself from connecting coaching moves from individual coaches in order to minimize any potential biases from my study.

At times, I had to be cautious of which data samples I used in my analysis, to ensure the anonymity of coaches who could be potentially identifiable due to the small number of mathematics coaches working in the school district at the time of my study.

These were coaches I knew and who knew one another outside of this study. I attempted to maintain anonymity by both focusing on coaching cycles rather than coaches, as well as by examining episodes of coaching moves rather than entire coaching conversations in my analysis chapters. Although I removed as many identifying characteristics as possible from the data, by numbering coaching cycles instead of using pseudonyms, and using dates rather than identifying characteristics to label the interviews, for example, it is possible that the coaches may be able to identify themselves at certain points in my analysis and discussion due to the content of the conversation in these samples.

This also brings to light another potential limitation that can occur due to my insider perspective as a researcher. My pre-existing relationships with all six coaches who participated in the study, though helpful in establishing rapport to ensure coaches shared meaningful data with me, could lead to bias in the observations, field notes, and interviews. In order to address such bias, I attempted to maintain an objective lens while writing field notes and during conversations with coaches and teachers. In several instances where the coach would ask for advice on their work with a classroom teacher, I would complete the formal data collection before engaging in conversations related to the work of the coach to attempt to separate the research from my personal views. I took notes on and recorded these conversations with coaches to reflect on my interactions and my note taking further after the coaching cycles were done. It was through steps such as these that I attempted to minimize any limitations my role as the researcher may have had during each step of the data collection and analysis.

In this Chapter, I described the analytical tools that I developed to examine my data around my research question and two sub-questions. I shared step by step the types of data I collected, and how I proceeded to examine my data in three initial rounds of analysis: first, to determine the types and frequency of MTT teachers discussed, next, to determine the types of coaching moves that initiated this teacher talk, and finally, the types of contextual factors that were present across these conversations.

In Chapters 4, I take the results of this coding and data examination and attempt to develop a theory of what constitutes productive coaching when the coaching goal is centered around shifting teacher practice toward reform-based teaching approaches. Chapter 4 focuses on how I used my data analysis to develop a multi-layered definition of "productive" coaching conversations, and of what constitutes a range of "productive coaching moves" when coaches attempted to help teachers attend to mathematical tasks of teaching across my data. I also offer a discussion of the ways in which my data analysis led to a deeper understanding of the types and frequencies of contextual factors present throughout the coaching cycles in my study. This chapter looks across my data to broadly understand the features of coaching conversations that were less and more productive.

In Chapter 5, I present a closer examination of this range of productive coaching moves across my data that occurred throughout these coaching conversations in ways that were less and more productive. I offer vignettes and examples to illustrate the features of each of these types of coaching moves and conversations, in order to help the reader understand the features of productive coaching moves that resulted in teachers attending or not attending to MTT. Additionally, I examine the interplay between the contextual factors that were present throughout coaching cycles that consisted of a range of productive coaching moves, in an attempt to better understand what influence, if any, these factors may have had on the productivity of this coaching work with teachers.

Chapter 4

Findings in Examination of Productive Coaching Moves and Contextual Factors

Examining planning and debriefing conversations between coaches and teachers to understand how coaches help teachers incorporate a range of mathematical tasks of teaching in their practice is a complex process. In order to answer the first sub-question of my research regarding the types of "coaching moves" that tended to be most productive in advancing talk around MTT, I first had to determine what productive coaching moves looked like when these moves helped teachers attend to MTT. Although coaches may enter coaching conversations with a range of goals, in this study I focused around the coaching goal of helping teachers attend to a range of MTT in their planning and debriefing. In this chapter, I develop two working definitions of "productive" coaching moves as they occurred in my data with this goal in mind. First, when coaches used the specific types of coaching moves the literature in Chapter 2 suggested, they "productively" promoted teachers' abilities to attend to a wide range of mathematical tasks of teaching. Second, when coaches helped teachers make connections among the three broader themes of these MTT, conversations were focused on mathematics more deeply than those where this did not occur.

This chapter shows the results of the coding and analysis from Chapter 3 in order to help the reader understand how I developed a definition of productive coaching moves based around the categories and counts of MTT that coaching moves helped teachers attend to. I present examples of the types of coaching moves found in my analysis that connected the general coaching moves promoted by the professional literature on coaching to my framework of examining coaching in terms of the extent to which coaching moves help teachers attend to MTT. I examine the specificity of coaching moves with regard to MTT, and how the enactment of these moves tended to result in more or less productive instances of coaching across my data, as well as the extent to which these moves helped teachers make connections between MTT themes. Finally, in this chapter I discuss my findings of the types and frequency of contextual factors present in my data using the framework presented by Smith, Hayes, and Lyons (2016) in Chapter 3 to better understand the potential influence of these factors on the productivity of coaching moves and coaching conversations in my study.

As I discussed in Chapter 2, helping teachers to develop mathematical goals, posing deep questions, offering ideas and suggestions, and pressing teachers to analyze student work and data are all “coaching moves” that the professional literature deems productive (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013). The research shared in Chapter 2 suggested that additional studies were needed to understand what coaching moves look like that effectively help teachers attend to mathematical tasks of teaching and develop reform-oriented mathematics teaching practices. In this chapter I attempt to more closely examine what defining these productive coaching moves looks like in practice. Even when coaches attempted to use “productive moves” to engage teachers in talk around MTT, my data suggests a second definition of “productive” also came into play. Not only were the individual moves that a coach made more or less productive, but the patterns of coaching moves as the coach enacted them lent conversations to be more or less productive in helping teachers attend to MTT. In this chapter, I analyze and explain these different definitions of “productive coaching moves” and “productive patterns of coaching moves" as they occurred throughout my data. I do so to develop a clearer understanding of how mathematics coaches crafted conversations with teachers in the ways that they did in an attempt to focus the reflection and analysis of the teachers with whom they worked around a range of MTT.

Defining Productive Coaching Moves in Planning and Debriefing Conversations

In Chapter 3, I presented the three rounds of coding and counts I did for my initial data analysis around teacher discussion of MTT and MTT themes, and of the coaching moves that led to this teacher talk. In this chapter, I use these findings to examine patterns of conversation between the coach and teacher. My initial rounds of coding (at this level without any regard to the length or depth of the comments) allowed me to develop a series of tables with information about these conversations in order to further examine how productive coaching moves tended to be in helping teachers attend to MTT. The tables allowed me to look for trends that emerged throughout first the planning and then the debriefing conversations around how many and what types of MTT coaches and teachers tended to talk about in ways that went beyond my initial coding and counts.

Table 7 breaks down the instances of how many different MTT a teacher brought up around each of the broader three MTT themes from the initial coding I did of teacher responses to coaching moves in planning conversations. The table also includes a shaded column that denotes the total number of distinct MTT from within the MTT themes the teacher discussed during planning. It is important to note that I organized the table based on the counts in this column, to create a picture of how heavily the work of the coach and teacher focused on these MTT themes during conversations. Since the professional literature stressed the need for coaches to focus on similar topics, this was of particular interest during my analysis. I also included a column with the recorded duration of the conversation to see if there were any patterns between productive coaching moves and the length of the coaching conversation itself for my examination of contextual factors.

Table 7

Planning Conversation Counts of Mathematical Tasks of Teaching (MTT)

Cycle Info	Number of Tasks Around Math Goals	Number of Tasks Around Problem Design	Number of Tasks Around Student Knowledge	Total Tasks Around 3 MTT Themes	Length of Conversation (in minutes)
Planning 15	0	1	1	2	9:30
Planning 8	1	1	0	2	23:11
Planning 4	1	1	1	3	22:43
Planning 10	1	1	1	3	20:11
Planning 14	1	1	1	3	11:21
Planning 9	1	2	0	3	17:14
Planning 22	1	1	2	4	22:11
Planning 3	1	2	1	4	31:01
Planning 18	2	1	1	4	18:19
Planning 19	1	0	3	4	19:45
Planning 20	2	1	1	4	33:20
Planning 13	2	1	2	5	10:21
Planning 23	1	2	2	5	24:38
Planning 24	1	3	2	5	24:52
Planning 5	2	1	2	5	28:59
Planning 7	2	2	1	5	25:00
Planning 17	2	2	2	6	24:27
Planning 21	2	2	2	6	35:21
Planning 25	1	3	2	6	39:57
Planning 26	2	2	1	6	28:07
Planning 27	2	1	3	6	39:01
Planning 16	3	2	2	7	36:50
Planning 2	2	2	3	7	28:46
Planning 11	2	2	3	7	28:48
Planning 12	2	2	3	7	17:03
Planning 1	2	3	3	8	25:16

My goal in creating this table was to better see the trends in my findings related to the type and frequency of MTT discussed during planning in order to develop a better understanding of what productive coaching moves look like. In reflecting on the information in Table 7, the evidence suggested that in some planning conversations, teachers focused their talk on a broader range of MTT from each of the three MTT themes, resulting in a greater number of overall tasks discussed during planning. Near the bottom of the table, planning conversations had a higher total count of tasks from within MTT themes. Additionally, these planning sessions typically had 2 to 3 distinct tasks in each of the individual theme columns as well. This indicated that not only did the teacher consider tasks around goals, problem design, and student thinking within the conversation, they also considered *multiple* tasks from within each MTT theme. Helping teachers to consider multiple facets of these three themes within a single conversation indicates the potential presence of more productive coaching moves that helped to foster teacher attention to this broader range of tasks.

Looking down Table 7, some of the counts were less balanced across the individual column counts for each of the three MTT themes. For example, I sectioned off the middle of the table to highlight planning conversations that tended to have one of the MTT themes talked about less frequently than the other two themes in a given conversation. In particular, there were only six instances where the counts of MTT around mathematical goals were fairly balanced with the other two themes, and only three planning sessions when mathematical goals were the prominent theme. Helping teachers to set mathematical goals is one of the professional literature on coaching's suggested coaching moves, so it is of particular note that it was not as prevalent in my findings as the other two MTT themes. Near the top of Table 7, some of the columns for individual MTT themes included zero counts, indicating that the coach did not help the teacher consider all three themes within a single conversation. If helping teachers attend to a range of MTT and to attend with more depth is important to the work of the teacher, as Ball, Thames, and Phelps (2008) suggest, it is necessary to further examine what coaches did or failed to do in conversations where an entire MTT theme was absent during planning.

In examining the last column of Table 7, it is worth noticing that typically when the total count of MTT discussed was higher (6 or more total MTT), the duration of the coaching session tended to be around 24 minutes or longer, with the exception of Planning 12, a 17:03 minute conversation. Since temporal factors were of interest in my examination of contextual factors that influenced coaching cycles, I wanted to examine the possible relationship between the length of the planning session and MTT discussed during the session further. Therefore, I used statistical analysis to determine whether there was a correlation between the two factors, as seen in Figure 4.

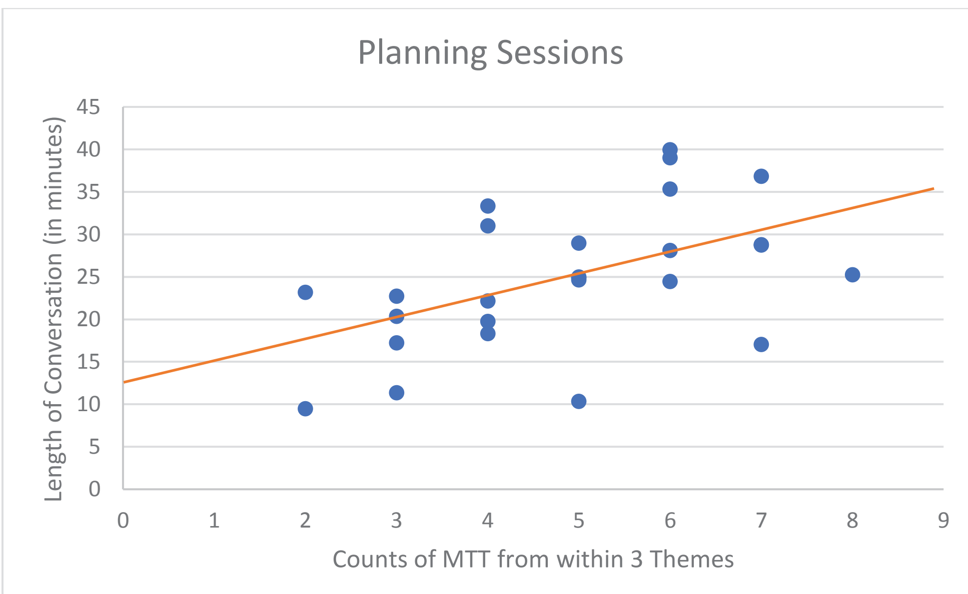

Figure 4. Length of planning sessions compared to MTT discussed during planning.

In doing this analysis, I found a correlation coefficient of r^2 = .2597, which was somewhat correlated. There was a somewhat high standard deviation (e.g., mean time is close to 25 minutes, with a standard deviation of over 8 minutes). I found a mean MTT of

4.9, with a standard deviation of 1.7. The line of best fit for this data was y=2.54x+12.47 (where time was written as a decimal), showing that for approximately every two and a half additional minutes of planning, an expected one additional MTT would be discussed. If having additional time to talk with teachers increases the expected counts of MTT teachers attend to, it important to understand the types of temporal factors that potentially influence planning sessions and whether coaches can mitigate the effects of these factors on the productivity of their work with teachers.

As I discussed in Chapter 2, temporal factors were often cited as being problematic in the work of the coach, so it was important to examine instances where this was and was not the case in my data. Interestingly, planning conversations with 5 or fewer total MTT at times were still fairly lengthy, with 10 planning conversations that broke the twenty-minute mark, further indicating that length of conversation did not always directly relate to the productivity of the talk with regard to number of MTT discussed, despite evidence of some correlation between these factors. Time is a contextual factor that is at times beyond the ability of the coach to control. This makes it critical to understand what coaches did to enact productive coaching conversations *despite* the often present limitations of time. My data suggests that in some instances, the length of the conversation may have been more of a factor in determining the productivity of talk that engaged teacher conversation around MTT than in other, briefer conversations.

I used a similar process in how I created Table 7 to develop Table 8 for examination of my level one findings for the debrief sessions. As I stated in Chapter 3, since the debrief and planning occurred at separate times, and sometimes debriefs did not occur in person or at all, I decided to examine them as separate coaching sessions from their planning counterparts. Most of the debriefs occurred in person. The in-person and two email debriefs I had access to were coded in the same manner as the planning sessions for instances of teachers discussing MTT around the three MTT themes. Although the overall organization of Tables 7 and 8 were the same, the reader should note that the counts for total tasks in the three MTT themes were lower overall in the debriefs than in the planning sessions, meaning that coaching moves led to talk around less MTT than in the planning. There was also perhaps a little more variance in the length of conversations across the debriefs than in planning. Understanding what may have led to lower counts of MTT in the debriefs, as well as whether the typically briefer timespan of the debrief sessions factored into this, could help inform how coaches can enact debrief sessions in ways that include more productive coaching moves in future coaching work.

Table 8

Debrief Counts of Mathematical Tasks of Teaching (MTT)

Cycle Info	Number of Tasks Around Math Goals	Number of Tasks Around Problem Design	Number of Tasks Around Student Knowledge	Total Tasks Around 3 MTT Themes	Length of Conversation (in minutes)
Debrief 15	0	0	1	1	7:23
Debrief 18	0	1	1	2	28:18
Debrief 20*	0	1	1	2	email
Debrief 13	0	2	1	3	7:01
Debrief 17	1	1	1	3	27:27
Debrief 22	2	0	1	3	11:11
Debrief 23	1	1	1	3	14:59
Debrief 14	1	1	1	3	12:01
Debrief 5	1	1	1	3	20:25
Debrief 12	1	1	1	3	19:03
Debrief 3*	1	1	1	3	email
Debrief 24	2	1	1	4	26:41
Debrief 25	2	1	1	4	29:11
Debrief 9	1	2	1	4	12:42
Debrief 21	1	1	2	4	33:21
Debrief 26	1	2	1	4	21:05
Debrief 27	1	2	1	4	24:30
Debrief 7	1	2	1	4	18:50
Debrief 10	1	1	2	4	21:25
Debrief 16	1	1	3	5	32:16
Debrief 1	1	2	2	5	27:57
Debrief 11	1	1	3	5	16:17
Debrief 2	1	3	3	7	13:05

Note: * Denotes cycle where debrief was conducted by email

Although I organized Table 8 with the same types of counts and categories as the previous table, the patterns in this table were slightly different. First, the overall counts of total tasks around the MTT themes as indicated by the shaded column tended to be lower than those of the planning conversations. Second, although the debriefs with the highest total counts still included a range of MTT from across the three themes, conversations were often less balanced in how many times each MTT theme was discussed. Many debrief conversations had one MTT theme column with a count of only 1 while the other two columns had higher counts. For example, there were only three debrief conversations in which the count of MTT around mathematical goals was higher than the other two

MTT themes. This was similar to the trend that occurred in planning sessions with regard to goals.

More often than not, teachers talked about problem design and student knowledge and mathematical thinking rather than goals in the debrief. Debrief sessions where more than 4 to 5 MTT around all three themes were discussed were rare in the data, and when the count was fewer than 4 total MTT, 6 out of the 11 debriefs that fell into this range had a zero count in at least one of the columns, indicating that the conversations did not focus on all three MTT themes in over half of the debriefs. If the goal of coaching moves and these conversations is to help teachers consider a range of MTT as it relates to their teaching practice, these findings indicate that some of the debrief conversations were much less productive than others in achieving this aim across my data.

With regard to length of the conversations, there was also a bit more variance in the debriefs than in planning sessions when comparing a correlation between the length of the session and the count of MTT discussed, as Figure 5 shows.

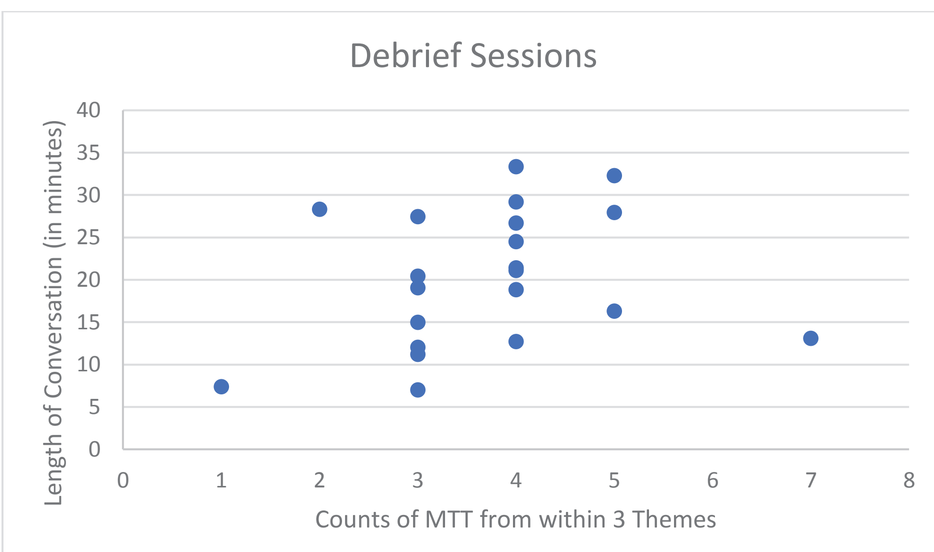

Figure 5. Length of debrief session compared to MTT discussed during debrief.

With the debrief, the mean minutes of conversations was 20.2, with a standard deviation of approximately 8 minutes. The mean MTT discussed was 3.7, with a standard deviation 1.2. I determined a correlation coefficient of r^2= 0.0555, so there was essentially no correlation between the length of conversation and count of MTT discussed. Unlike the planning conversations, the counts of MTT discussed and time spent debriefing did not follow a simple correlational pattern. Therefore, understanding what led to more or less productive instances of coaching moves in debriefs cannot be understood based on the length of the conversation alone.

Following this trend, although some debriefs with the highest total count of MTT tended to be longer in nature, one notable exception was Debrief 2, which had a length of only 13:05 (nearly 1 standard deviation below the mean), yet had the highest overall count of MTT discussed in a debrief. Similarly, although typically the debriefs with low overall counts of MTT tended to be shorter, one of the lowest count, face to face debriefing conversations that occurred was over 27 minutes long, despite this time being nearly 1 standard deviation from the mean. Such findings indicate that there was more to determining what makes a productive coaching conversation than time alone.

Multiple Definitions of "Productive"

In Chapter 2, I examined what the current professional literature on coaching broadly defined as "productive coaching moves" for elementary mathematics coaches. Although there was some variance from source to source, most of the literature suggested a core repertoire of moves should be at the heart of the coach's work during the three-part coaching cycle to promote reflection and shifts in teaching practice around mathematics, as shown in Figure 6.

Setting goals

Posing questions

Sharing ideas or suggestions

Actively listening

Helping teachers to analyze data and student work

Figure 6. "Productive coaching moves" as suggested by the literature (adapted from work by Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013; Huguet, Marsh, & Farrell, 2014).

The challenge for coaches is to understand how to use these coaching moves in ways that are productive, and so it is equally important to understand how each of these moves can be utilized when considering each of the MTT themes. Therefore, I needed to more clearly define what it looked like for these moves to play out "productively" in terms of this study, where the goal was to help teachers consider and refine their thinking and planning around the mathematical tasks of teaching.

In examining the broader coaching moves in Figure 6, they can be tied directly back to coaching around the three MTT themes I developed in Chapter 3 (see Table 4). Coaches helped to define goals around the mathematics of a lesson, posed questions or offered suggestions that fostered discussion around each of the MTT themes, and helped teachers analyze student data to inform their instructional planning. Therefore, in defining what it meant for the coaching moves of mathematics coaches to play out productively, it was important to consider the extent to which they helped teachers focus on the mathematical tasks of teaching central to these themes and helped them consider actions for their teaching based on these conversations. In Table 9, I adapted my work from Table 4 in Chapter 3 to show how these "productive coaching moves," as defined by the current professional literature on mathematics coaching, aligned to the three MTT themes.

Table 9

Examples of Productive Coaching Moves Around the Three MTT Themes

Mathematical Tasks of Teaching Themes	Examples of Productive Coaching Moves (Based on the Professional Literature)
Mathematical Goals	• Posing questions around mathematical goals • Offering ideas and suggestions around mathematical goals • Prompting use of data/student work analysis to inform mathematical goals
Mathematical Problem Design	• Posing questions around mathematical problem design • Offering ideas and suggestions around mathematical problem design • Prompting use of data/student work analysis to inform problem design
Examining Student Mathematical Knowledge and Ideas	• Posing questions around students' mathematical knowledge or ideas • Offering ideas and suggestions around students' mathematical knowledge or ideas • Prompting use of data/student work to analyze students' mathematical knowledge or ideas

These more specific versions of coaching moves became an integral part of my second round of coding, and these themes are situated in my analysis of coaching moves going forward. It is important to clarify that coaches may also talk about "goals" that were unrelated to the mathematical goals of the lesson, for example setting coaching goals for themselves, or setting teaching and learning goals for the classroom teacher during the coaching cycle. Similarly, coaches may have posed questions and offered ideas or suggestions that were unrelated to MTT during their conversations with teachers. In Chapter 2, I discussed a need for future research to examine which coaching moves were less and more productive in helping teachers to focus around reform-oriented teaching practices that help them attend to a range of MTT. This table offers a starting point in understanding what it means for coaching to be "productive" with regard to coaching moves around MTT. In the following sections of this chapter, I more fully develop working definitions of "productive" as coaching moves and conversations played out in practice during the three-part coaching cycles around these MTT.

"Productive" as coaching moves that connect to mathematical tasks of teaching. My second round of coding in Chapter 3 sought to identify coaching moves that included the broader moves of posing questions, offering examples, ideas, and suggestions, and pressing teachers to examine data or student work. I also wanted to examine whether or not the coach worded the move in such a way that specifically connected it to one of the three MTT themes. In some instances in my coding, there were more generically posed moves (not worded in ways that focused around MTT) included as well because they still led to the teacher talking about one of the MTT. Table 9 shows the categories I developed for examining both the coaching moves that attempted to initiate talk around the MTT themes in my second level of analysis, as well as teacher responses from my first level of analysis, whether they were tied to a particular MTT or not. Table 10 is categorized first around the MTT theme, then by the coaching moves in the data that were specific to each theme, and finally by the categories of teacher responses (both related and unrelated to MTT). Through this examination I found that, typically, the more specifically coaching moves were worded around MTT themes, the more likely teachers were to respond with talk around MTT, yet this was not always the case.

Table 10

Level One and Two Findings of Coaching Moves and Teacher Responses

MTT Themes	Coaching Moves to Press MTT Themes	Teacher Responses around MTT
Mathematical Goals	QMG = Posing questions about mathematical goals QG = Posing questions about goals related to teaching SMG = Offering suggestions about mathematical goals RMG = Restating mathematical goals	FE = Finding examples to make a specific mathematical point LR = Linking representations to underlying ideas and other representations AA = appraising and adapting the mathematical content of textbooks
Problem Design	QPD = Posing questions about mathematical problem design QPS = Posing questions about the organization and set up of the problem/activity SPD = Offering suggestions about mathematical problem design SPS = Offering suggestions about the organization and set up of the problem/activity	PI = Presenting mathematical ideas AQ = Asking productive mathematical questions MT = Modifying tasks to be either easier or harder OL = Considering organization and logistics
Student Knowledge or Thinking	QAS = Posing questions to anticipate student mathematical thinking/strategies QES = Posing questions about examples of student mathematical thinking/strategies QBS = Posing questions about student background knowledge of mathematics SES = Sharing examples of student mathematical thinking/strategies	RS = responding to students' "why" questions RR = Recognizing what is involved in using a particular representation SR = Selecting representations for particular purposes EC = Evaluating the plausibility of students' claims EE = Giving or evaluating mathematical explanations
Unrelated to MTT Themes	Q = Posing generic questions about the lesson SET = Sharing examples of teaching moves/collected data from lesson I = Interruption to conversation	CT = Connecting a topic being taught to topics from previous or future years EP = Explaining mathematical goals and purposes to parents CD = Choosing and developing useable definitions UN = Using mathematical notation and language and critiquing its use IE = Inspecting equivalences G = Generic comments T = Tangent from planning conversation

In organizing my findings in this way, I made several important observations about the types of coaching moves made in planning and debriefing sessions with regard to how certain types of coaching moves led to more or less specific responses from teachers around MTT. First, the coaching moves themselves in some of the conversations were sometimes more generic rather than relating to a specific MTT or MTT theme. For example, the coach might pose a question about the lesson set up in general ("Tell me what you're planning…"), without prompting a discussion of the actual mathematical problem design at the heart of the lesson, or they might ask about goals without specifically framing the question in such a way that got at the explicit mathematical goals for the lesson. In some coaching cycles, this move still led to teachers talking in detail about their plan for the lesson, including the mathematical problem design and mathematical goals, but not always. Even when coaches did try to use moves that were specific to MTT, these moves at times led to non-specific remarks from the classroom teacher, or talk around organization and logistical issues. Such issues included how to group students, what materials to use, how long certain lesson components might take, or what structures to use to increase student engagement, rather than the mathematics at the heart of the lesson. This indicates that, at times, teachers were unaware of the coach's attempts to steer their focus toward particular MTT, and the conversation remained at more of a surface level than in instances where coaching moves led to in depth talk around the three MTT themes.

The categories of coaching moves that emerged from the findings presented in Table 10 provided additional insight into the work of coaches that made coaching moves "productive." One facet of these moves that mattered in my data was the level of specificity with which the coach attempted to focus the conversation around particular MTT and on MTT themes through their coaching moves. When the coach failed to pose a question or offer an idea in ways that pressed teachers to tie directly to these big picture mathematical teaching themes, the moves played out less productively than instances where the conversation remained focused around planning and reflecting around MTT. Another key insight from Table 10 was that it was not only the move that the coach made that mattered, but also how the teacher responded to the move that could determine the productivity of the move. This indicates that it was not just the way the way the coach worded or timed a particular move that was important, so much as how the move provoked the teacher to respond. When coaching moves did not lead to teachers attending to MTT, the moves were less productive. Figure 7 shows the enactment of coaching moves in these ways.

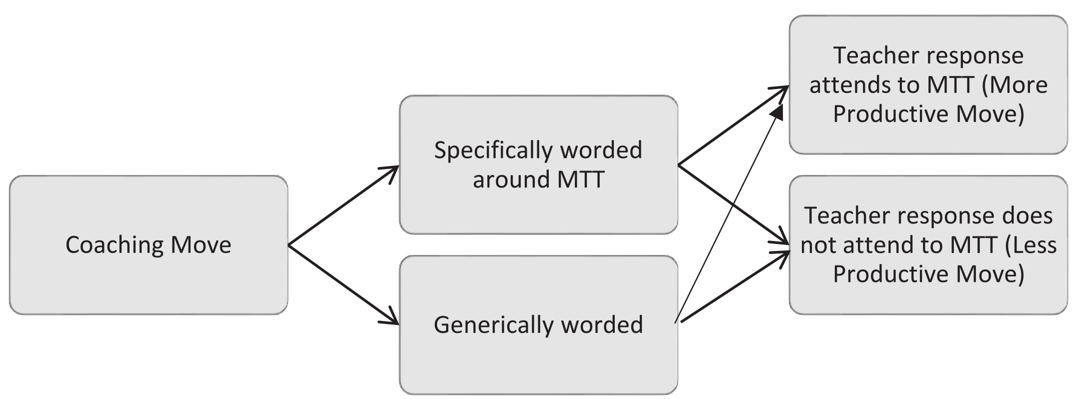

Figure 7. Enactment of less and more productive coaching moves.

As Figure 7 shows, the enactment of a particular coaching move begins with either a generically phrased coaching move or one that is worded specifically to help the teacher attend to MTT. My determination of the productivity of these moves did not solely rely on the phrasing of the move itself though. The way in which the teacher responded, by reflecting and analyzing on a particular MTT or by offering a more generic statement, determined whether or not the coaching move was productive or not. This is similar to the work of Smith and Stein (2011) around orchestrating productive classroom discussions. The authors in this text defined “productive” as being dependent on whether the discussion remained focused and whether or not students made the mathematical connections intended by the teacher. Similarly, when teachers do not make the connections implied by the coaching move, this typically results in unproductive conversation.

In Chapter 2, I examined a study by Olson and Barrett (2004) where the researchers found that at times, even when teachers worked with coaches to understand and incorporate reform-oriented practices in their instruction, sometimes the teacher remained focused on using traditional instructional approaches. In my findings, even when coaches posed questions, or offered ideas and suggestions that led to teachers reflecting on MTT in some cycles, in other cycles these coaching moves led to generic or non-mathematics related responses instead. If the teacher did not “go there,” the coaching move in isolation was relatively unproductive. This indicates that where the coach went next in the conversation mattered. Sometimes coaches followed up the move and probed the teacher further about the topic at hand. Other times, the coach moved on to the next point in the conversation, without pressing the teacher further to respond. Such follow up choices mattered in determining the overall productivity of such coaching moves. This indicates that at times it is a string of moves that matter, rather than a single move, in helping teachers consider MTT in their planning and debriefing. It also suggests that there is not necessarily an “ideal” set of coaching moves, rather the coach must work to be responsive to each teacher and coaching situation individually to have productive conversations around MTT.

Tables 7 and 8 demonstrate that the number of MTT around the three MTT themes that coaches pressed teachers to talk about also mattered in determining the overall productivity of the coaching conversation. Therefore, in taking the definition of "productive coaching moves" a step further, it is important to go beyond considering individual coaching moves as they play out in the moment. It is also important to recognize how these moves worked together to paint a complete picture of the coaching conversation with regard to productivity.

"Productive coaching moves" as fostering interplay between goals, problem design, and student knowledge. Examining the outcome of individual coaching moves during planning and debriefing conversations was not the only way that I analyzed my data to find evidence of "productive" coaching. As I examined my findings around the number of MTT coaching moves led to teachers reflecting on, I began to notice that in some instances, coaching moves did not only promote reflection on individual MTT in isolation. At times, the coaching moves were worded in such a way that they pressed teachers to consider potential connections between the three MTT themes of mathematical goals, problem design, and students' mathematical thinking. In doing this, coaches were often able to help teachers see the potential interplay and relationships among these themes in their planning and teaching. When coaches attempt to help teachers make these sorts of connections, this relates to Lampert's (2001) work around teaching practice, where she discussed the connections between the teacher, mathematical and pedagogical content, and the student as intertwined relationships within which mathematical teaching practice developed. Lampert illustrated this interplay between teacher, content, and students using a triangular model (Figure 8), which she used to explain the dynamic between each component.

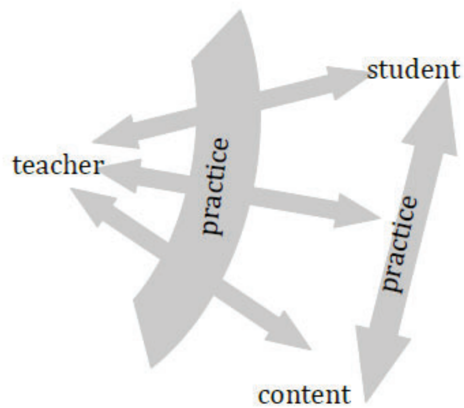

Figure 8. Lampert's model of the teacher-student-content relationship (Lampert, 2001, p. 31).

Lampert described the arrows between the actors in her triangle as the "problem space" where the connections between the teacher and their knowledge of students, the teacher and their knowledge of the mathematical content, and the students' knowledge and anticipated ways of interacting with the content can influence lesson design and enactment. In examining her own teaching practice, Lampert focused on "…problems of lesson preparation, which involves figuring out how to connect particular students with particular mathematics" (p. 101), and described a need to plan mathematics lessons that both met the goals of the content but were also responsive to students' knowledge and ways of thinking mathematically. She described deciding what students would be expected to do (connected to mathematical goals and objectives) at the same time as considering how to "…figure out what kinds of activities particular problem will elicit from the students in my class, and specify how the activities implied by the problem can support the teaching and studying of the intended subject matter for these students" (p. 119). When coaches utilize coaching moves that move teachers to see the connections between the three MTT themes, they help teachers consider these "problem spaces" in ways that can increase the teacher's ability to plan and enact impactful mathematics lessons.

This work of developing mathematical goals that takes into account the students' existing knowledge, as well as anticipating how students might approach working through particular mathematical activities and how this affects the problem design connects directly back to my examination of MTT themes in coaching conversations. When coaches attempt to foster connections between the three MTT themes in planning and debriefing conversations with classroom teachers, they allow teachers to consider all of the layers of these "problem spaces" of the teacher, students, and content, and how these layers may potentially interact with one another during the lesson. Teachers have goals in mind that help shape the problem set-up and to narrow the focus of the content they plan to teach. They must also take into consideration the prior knowledge and experiences of students around this content, the learning styles and modalities of their students, and anticipate the potential misconceptions and challenges students may face as the teacher designs the lesson. By ensuring that teachers consider how each of the themes interact, coaches can help teachers more thoroughly prepare lessons in ways that are responsive to their mathematical goals and the needs and understanding of their students simultaneously. The work of coaches around MTT is similar to the work that Lampert described doing in her research of her own teaching practice. In order to understand how and when instances of this occurred in my data, I also sought to examine the attempts of certain coaching moves to bridge connections between these themes.

Examining the tables in the previous sections of this chapter led me to notice that what is relevant about coaching moves can go beyond just how many MTT the teacher talks about during a coaching conversation and which coaching moves help teachers make connections between and among MTT themes. While coding for coaching moves and teacher responses in rounds one and two of my analysis, I saw that at times some of the coaching moves pushed teachers to consider making connections between and among MTT themes throughout the planning and debriefing, rather than talking about the themes in isolation. I wanted to understand more about what it looked like for coaches to do this, and began to reexamine my data in light of these ideas. As I considered what it was that made certain instances stronger than others in terms of the extent to which teachers considered the interaction of multiple MTT themes, I began to notice patterns in how these coaching moves played out in conjunction to the MTT that were discussed as a result in different conversations.

At times, there was little evidence that the coaches were able to move teachers toward talking about all three MTT themes with any depth. Other times, despite attempting to discuss multiple MTT themes with teachers, these moves played out in ways that were seemingly disjoint and disconnected. Alternately, however, there were cycles where the coaching moves worked to weave back and forth across these MTT themes, and it is within these episodes that perhaps the most productive conversations around the work of teaching and learning mathematics seemed to occur. Ball, Thames, and Phelps (2008) describe the knowledge teachers need related to content and teaching as an “amalgam” (p. 402), and explain that much of this knowledge is at the intersection of these MTT themes. This is in line with Lampert’s triangle (2001), and her description of the interplay between the various actors involved in mathematics teaching as well. Therefore, it became apparent in my later analysis of my first and second level findings around coaching moves and teacher responses to these moves, that when coaching moves can help teachers recognize the connections and interplay among these themes, they can increase teacher capacity to attend to these MTT across their practice.

This brought about an observation that perhaps it was not just about having a range of moves in terms of whether coaches asked lots of questions, for example, so much as whether they used coaching moves that got teachers connecting to MTT themes. The most robust examples of coaching conversations with regard to the extent to which the coach and teacher discussed mathematical content and pedagogy were those where coaching moves were used strategically to not only *move* teachers from considering one MTT theme and then another, but to help teachers *make connections* between the MTT themes. With this new definition of “productive” coaching moves in mind, I returned to my findings around coaching moves and re-examined them for evidence of times when the coach attempted to make a connection between one or more of the three MTT themes within a given coaching move (step two of round two analysis) and whether the teacher took up the conversation around MTT as a result. As I reanalyzed coaching moves that were originally coded as specific to a particular MTT, I reread the coaching move and any follow up moves that came after an initial teacher response to see if the coach phrased the move in such a way that it asked the teacher to consider one theme in terms of another (e.g. “What do you think students will come up with if you present the problem in that way?" or "In what ways does your problem design align with your mathematical goal for the lesson?").

Table 11 shows the counts of coaching conversations where one or more coaching moves pressed the classroom teacher to consider making a link between one or more types of the three MTT themes. For example, a coaching conversation where coaching moves resulted in helping a teacher make a link between their mathematical goal and the problem design, but failed to make connections between problem design and student thinking or mathematical goals and student thinking was counted as a conversation where one type of link was made. When the coaching moves led to links between two MTT themes were made, say mathematical goals and problem design *and* between mathematical goals and student thinking, for example, it was coded as a conversation where two link types were made. In the somewhat rare case that all three types of connections came about within a single conversation, they were coded as having three links made. This last level of analysis on coaching moves created another layer in my working definition of "productivity."

Table 11

Coaching Moves that Made Links Between MTT Themes

Type of Coaching Conversation	Conversations with No Links	Conversations with 1 Type of Link	Conversations with 2 Types of Links	Conversations with 3 Types of Links
Planning	9	6	9	2
Debrief	4	10	7	2
Total Conversations	13	16	16	4

The data in Table 11 suggests a fairly even amount of conversations took place where no links or one link between MTT themes were made by teachers as a result of these coaching moves, and slightly fewer conversations where two types of links were made. In only four of the 49 coaching conversations were coaches able to help the classroom teacher make links between all three connection types. These findings indicate that it can be challenging for coaches to enact coaching moves in ways that promote this sort of productive connection making between all three MTT themes all of the time.

In addition to examining the counts of link types between MTT themes, I was also interested in whether certain links occurred more often than not, in order to better understand which links may have been more challenging for coaches to make within a single conversation. Table 12 shows the number of coaching conversations out of the 49 total conversations where each type of link was able to be made, and the findings here indicate that not all links were made with equal frequency.

Table 12

Findings from Conversations Where MTT Links Were Made by Coaching Moves

Type of Link Between MTT	Number of Coaching Conversations
Links between mathematical goals and problem design	13
Links between problem design and student knowledge and thinking	32
Links between mathematical goals and student knowledge and thinking	13

As Table 12 makes clear, links between problem design and student knowledge and thinking were made most often, more than twice as often, in fact, as the other two types of links. This was perhaps not surprising, as in Tables 4 and 5 the counts of MTT around mathematical goals were often the lowest of the three MTT themes in both the planning and debrief. In order for coaches to foster links between all three MTT themes, it is important to better understand what it looks like when coaches are able to do this successfully.

To do this, I examined the coaching moves that I coded for the broad move type (posing questions, offering suggestions, examining data/student thinking) and the related MTT theme (see Table 4), and then counted the instances of these individual moves when coaches also attempted to create a link between two or more types of MTT themes. Table 13 shows the breakdown of the counts of individual coaching move types that attempted to make the three different types of links between and among MTT themes.

Table 13

Counts of Individual Coaching Moves Linking MTT Themes

Type of Coaching Move	Linking Mathematical Goals and Problem Design	Linking Problem Design and Student Thinking	Linking Mathematical Goals and Student Thinking
Posing question	11	41	12
Offering suggestion/idea	7	8	1
Sharing example/data	1	9	2
Other	3	0	2

As Table 13 illustrates, posing questions was by far the most prominent coaching move used to make all three types of links in coaching conversations. Linking mathematical goals and student thinking did not have a clear secondary coaching move that stood out in the data. When coaches attempted to promote links between mathematical goals and problem design, offering ideas and suggestions was the second most prominent coaching move used, and when trying to link problem design and student thinking coaches' secondary moves included both offering suggestions and sharing examples and data around student understanding.

To the extent coaches attempted to help teachers make connections among all three MTT themes within the frame of a single conversation, the findings presented in this section suggest coaches used some moves more frequently than others. When these more generic coaching moves of asking questions, offering ideas and suggestions, and sharing examples of student work and data were used with the goal of bridging these connections between and among MTT themes, they allowed coaches to create conversations that were "productive" at a potentially more significant level than individual productive moves did alone. Figure 9 presents a model of the most prominently used coaching moves that attempted to foster connections between the MTT themes throughout the coaching conversations in my data.

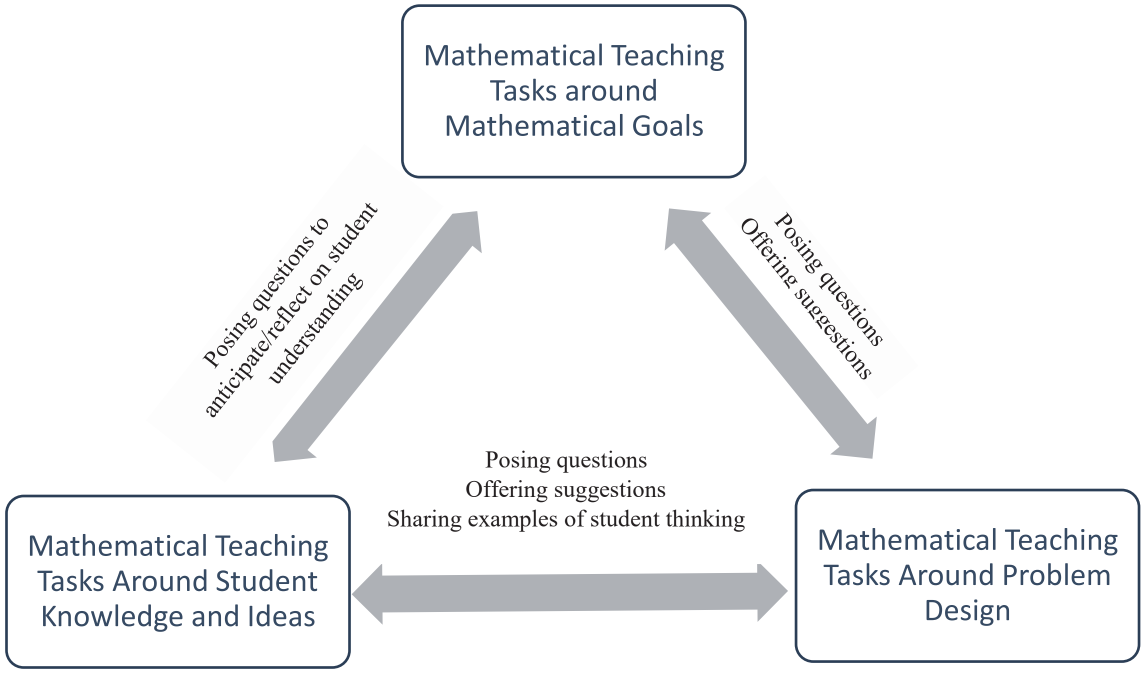

Figure 9. Relationship of coaching moves to MTT themes in productive coaching cycles.

To better understand what these definitions of "productive" coaching moves look like in practice, as well as how they interact with one another in the data, it is important to examine these coaching conversations in more detail.

So far in this chapter, I have examined my findings around what constitutes "productive coaching moves" when mathematics coaches engage in reflective and analytic conversations during the three part coaching cycle. My analysis brought to light several important findings:

- Coaching conversations tended to be more productive when coaching moves helped teachers attend to a broader range of MTT,
- the duration of planning sessions correlated to counts of MTT teachers engaged with, no correlation was found between duration of debrief sessions and counts of MTT,

- a range of literature-prominent coaching moves related to MTT were present in cycles, and
- multiple definitions of "productive" emerged in my findings
    - coaching moves where teachers engaging in discussion around MTT were productive,
    - coaching moves that fostered interplay between and among MTT themes were also productive, and
    - conversations with teachers were more productive when more links among MTT themes were made.

These findings offer a start to understanding how and what coaches focus on in substantive conversations with classroom teachers to help them attend to a range of MTT, as well as what sorts of coaching moves tended to promote teacher reflection and analysis of their teaching practice, as my discussion of the literature presented in Chapter 2 suggested needs to be better understood. In this chapter, I examined these findings at a broad level, looking for trends across all of the data about the work that coaches did across planning and debriefing conversations to attempt to engage teachers in talk around MTT. I found that the types of coaching moves presented by the professional literature tended to be enacted most productively when they were phrased in ways that tied them specifically to MTT, and that "productive" was a complex term that needed to be more clearly defined in light of my analysis and findings. To more completely answer my research question and sub-questions, and further address the existing gaps in the current literature, I must present a closer look into my findings.

In Chapter 5, I will present examples of coaching moves from within these conversations that demonstrate a range of "productivity," where the coaching moves are and are not able to help the teacher to consider a range of MTT, and I will examine the features of these coaching moves that may have led to less and more productive instances of coaching in different coaching cycles. Examining the counts and analysis presented in this chapter more closely can offer additional insights as to the overall nature of how these counts were connected to less and more productive attempts at enacting coaching moves within coaching conversations. I will also share examples where coaching moves do and do not attempt to foster the links between and among the three MTT themes in ways that could increase the connectedness of these tasks in productive ways. The following chapter will help to illustrate these coaching moves and their potential to influence the productivity of coaching conversations in ways that can help coaches and those who supervise and train coaches to better understand ways in which coaching moves can foster this deeper sort of planning and reflection around the MTT.

Contextual Factors and Their Potential Influence on "Productive" Coaching Moves

Although coaches typically attempted to use a range of productive coaching moves throughout my data, at times there was evidence of contextual factors that may have influenced the coaching conversation. My second research sub-question sought to better understand these factors and how they interacted with the productivity of coaching conversations. In Chapter 3, I developed a framework for coding factors around Smith, Hayes, and Lyons' (2016) ecological frameworks. Using this framework, I coded each of the planning and debriefing conversations, as well as the one-on-one interviews with teachers and coaches, for contextual factors, the findings of which are displayed in Figure 10.

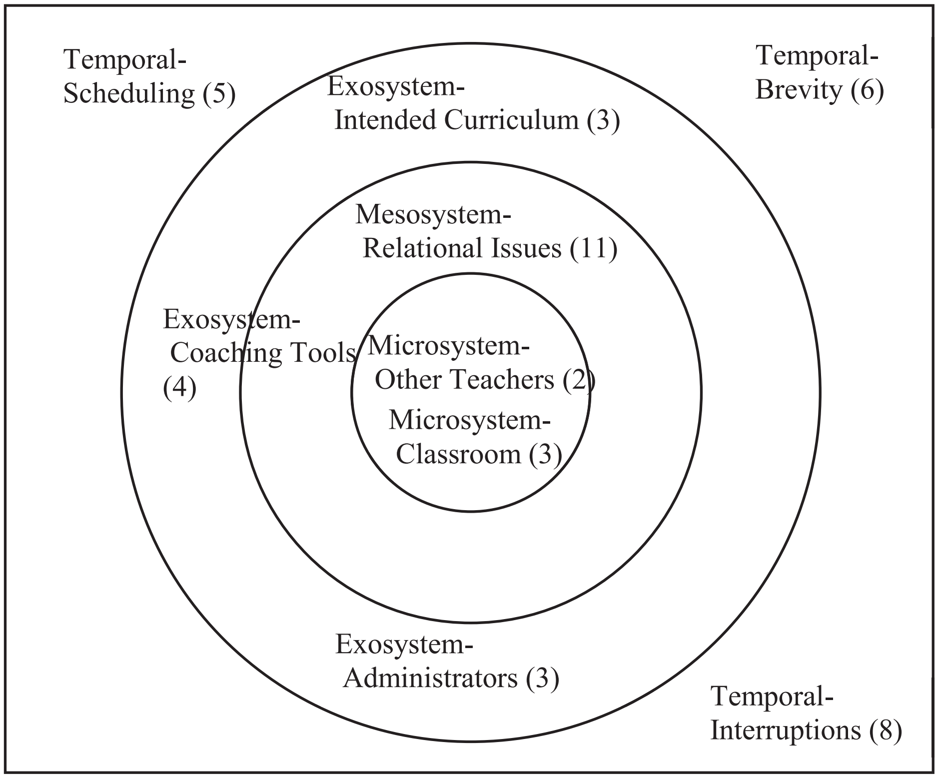

Figure 10. Counts and types of contextual factors present in coaching sessions.

I examined all of my data for evidence of coaches or teachers talking directly or indirectly about the influence of these contextual factors. I also used my field notes to look for evidence of contextual factors that may have presented themselves through non-verbal means that audio recordings may not have picked up on (i.e. the teacher repeatedly looking at the clock throughout the session, interruptions at the door, etc.). Throughout my data, most of the contextual factors that presented themselves were related to my anticipated coding categories of microsystems, mesosystems, and temporal factors. Although I anticipated having an "other" category, the two additional factors that came out of my data were in fact related to exosystemic factors, so I coded them as such.

Table 14 illustrates the range of exosystemic factors present across my analysis, as well as has the places in my data where I found evidence of these factors.

Table 14

Evidence of Exosystemic Factors Present in Analysis

Type of Exosystemic Factor	Where Counts of Factor Were Found
Coaching Tool	Planning 7 Transcript Debrief 7 Transcript Cycle 7 Field Notes Debrief 10 Transcript Cycle 10 Field Notes Planning 18 Transcript Debrief 18 Transcript Cycle 18 Field Notes Planning 19 Transcript Cycle 19 Field Notes
Intended Curriculum	Planning 4 Transcript Cycle 4 Field Notes Planning 6 Transcript Cycle 6 Field Notes Planning 10 Transcript Cycle 10 Field Notes

There were several instances where coaches used a "coaching tool," a protocol (often prescribed by the professional literature) that was intended to help guide the conversation with teachers. In a few instances in my data, I noted in my field notes the coach's inability to deviate from this script of questions (Ede, 2006) appeared to interfere with the coach's ability to make productive connections between MTT with the teacher. In three other instances, the mathematical content for the intended lesson (intended curriculum) did not lend itself toward particularly robust conversations around MTT. For example, in one planning conversation, the lesson that the teacher was planning for was an introduction to the academic vocabulary for the chapter. Although planning around a vocabulary-specific lesson would afford opportunities to discuss MTT such as, "Choosing and developing useable definitions" and "Using mathematical notation and language and critiquing its use" (Ball, Thames, & Phelps, 2008, p. 400), these MTT are not as directly linked to the three MTT themes. This lesson did not afford many opportunities to discuss student thinking, or problem design in ways that helped students make deep connections to the math.

The other three levels of factors that I coded (microsystemic, mesosystemic, and temporal) fell within the range of types of contextual factors I anticipated finding based on the work presented by Smith, Hayes, and Lyons (2016) and the other literature I examined in Chapter 2. There was evidence of microsystemic factors in five of the coaching conversations throughout my data. Table 15 illustrates the evidence of these factors across my data.

Table 15

Evidence of Microsystemic Factors Present in Analysis

Type of Microsystemic Factor	Where Counts of the Factor Were Found
Other Grade Level Teachers	Pre-Observation Interview Cycle 9 Cycle 9 Field Notes Pre-Observation Interview Cycle 27 Cycle 27 Field Notes
Classroom	Planning 2 Transcript Debrief 2 Transcript Cycle 2 Field Notes Pre-Observation Interview Cycle 15 Planning 15 Transcript Cycle 15 Field Notes Pre-Observation Interview Cycle 19 Planning 19 Transcript Cycle 19 Field Notes

In two instances, the coach cited the other teachers within a grade level making their work with a particular teacher problematic during their pre-observation interviews. In the other three instances, the classroom was included as a factor. In one situation, the classroom was coded as a contextual factor because the teacher's concerns about negative student behaviors influenced the aspects of MTT she was willing to consider during the planning session (Planning 19). The coach shared this concern with me during the pre-observation interview, and I examined both my field notes and the planning transcript for evidence of times when the teacher seemed hesitant to talk about particular MTT or take suggestions/ideas from the coach because of concerns as to whether her students could handle the lesson adaptation, in ways that were different from her prior work with this teacher. In one of the other conversations, the classroom became a factor because the debrief took place with students present at the end of the math lesson (Debrief 2). At times, this made it challenging for the conversation to remain focused around discussing the mathematics of the lesson, as the classroom teacher had to stop and attend to student concerns throughout the debrief. I made note of this in my field notes taken during the debrief, and there is some evidence in the transcript from the debrief of the teacher stopping the conversation to address classroom issues at multiple points in the debrief.

The coding categories with the highest counts of conversations demonstrating evidence of a particular contextual factor in my findings were those where mesosystem factors relating to perceived relational issues between the coach and teacher were present, and a range of temporal factors that occurred throughout the data. Relational factors were by far the most prevalent in my findings, which was unanticipated since coaches self-selected which teachers I would observe for my data collection. Table 16 illustrates where in my data I coded for evidence of these mesosystemic factors across the coaching cycles.

Table 16

Evidence of Mesosystemic Factors Present in Analysis

Type of Microsystemic Factor	Where Counts of the Factor Was Found
Relational Issues	Pre-Observation Interview 1 Post-Observation Interview 1 Pre-Observation Interview 9 Post-Observation Interview 9 Pre-Observation Interview 10 Post-Observation Interview 10 Pre-Observation Interview 14 Post-Observation Interview 14 Pre-Observation 19 Pre-Observation Interview 22 Post-Observation Interview 22

It is worthwhile to look at these conversations in more detail to better understand what coaches did in spite of or because of these perceived factors. In two coaching cycles, there was some evidence of the mesosystem between the coach and building administrator as having an influence on how often they worked with a particular teacher (as cited by the coach in the pre-observation interview in Cycle 1), and in one planning session, the administrator attended the planning session. At times, the presence and interactions of the administrator may have altered the direction of the conversation from the coach's intended work around MTT.

In examining the temporal factors, there were five instances where the coach or teacher referenced conflicts, either in their pre-observation interview with me or during the planning session with the teacher, such as having to go to bus duty, as reasons for either the brevity of or trouble scheduling a coaching conversation. There were six instances of conversations that were brief, less than 15 minutes in length, with no direct explanation offered as to why this occurred (see Tables 7 and 8). In three of these unexplained “brief” coaching conversations, the conversation was also coded as having a relational issue as well. It is possible that in these instances that the relational issues with the coach and teacher influenced the overall length of the coaching conversation.

In this chapter, I attempted to determine the types and frequencies of contextual factors across my data. I categorized these findings using the framework initially developed by Smith, Hayes, and Lyons (2016) and adapted in Chapter 3 to include the addition of temporal factors, in order to organize and understand my findings. My examination of contextual factors in this way suggests there several important things to note about the presence of contextual factors across my data:

- A range of factors were present across coaching cycles, including microsystemic, mesosystemic, exosystemic, and temporal factors,
- perceived relational issues between the coach and teacher (mesosystemic factors) and temporal factors were the most prevalent,
- teachers met with coaches in spite of the presence of mesosystemic and microsystemic factors a number of times,
- in a few instances, exosystemic factors that were beyond the control of the coach or teacher (administrators, intended curriculum) were present, and
- an unexpected exosystemic factor, the overreliance on coaching tools by the mathematics coach, was present in several instances as well.

In this chapter, I examined these contextual factors in isolation from my first research sub-question around the types of coaching moves used to initial teacher consideration of MTT in their planning and teaching of mathematics. These initial findings around contextual factors illustrate a need to re-examine the interplay of contextual factors within the context of the planning and debriefing conversations between coaches and teachers to develop a better understanding as to the extent that these factors may have influenced the productivity of the coaching moves across my data.

In Chapter 5, I plan to address factors related to: 1) microsystems with other teachers and classrooms, 2) mesosystemic factors related to perceived issues between a coach and teacher, 3) the exosystemic factor of overreliance on a professional tool, and 4) the range of temporal factors that came into play further. In order to answer my second research sub-question, it is critical to see how the presence of these factors interacts with the use coaching moves in more and less productive attempts to help teachers attend to and make connections among a range of MTT. Recognizing the potential benefits or hindrance of particular contextual factors on the productivity of coaching moves and coaching conversations can inform the field as to ways in which coaches work within the presence of such factors to engage in productive conversations that are focused around MTT with classroom teachers.

Conclusion

In this chapter I examined my analytical findings to develop a working definition of "productive" coaching moves by broadly examining planning and debriefing conversations between coaches and teachers. My goal in doing this was to develop a clearer understanding as to what productive coaching looks like in practice. By examining the categories of coaching moves and teacher responses in this chapter, I was able to create two definitions of what it means for mathematics coaches to enact "productive" coaching moves in their work with teachers. First, coaching moves are productive when they help teachers attend to a range of mathematical tasks of teaching. Second, coaching moves are productive when they help teachers make connection between and among the three MTT themes of mathematical goals, problem design, and students' mathematical knowledge and thinking. The literature suggests helping teachers notice and attend to these types of connections can help teachers develop their practice around teaching mathematics effectively (Ball, Thames, & Phelps, 2008; Lampert, 2001). In this chapter, I also identified the types and frequencies of contextual factors that were present across the different coaching cycles in my data.

In Chapter 4, I examined "productive" coaching moves in isolation from my analysis of the types and frequencies of contextual factors present across my data. It is important to understand whether the presence or absence of particular contextual factors can influence the productivity of coaching moves and coaching conversations in any way. Therefore, in Chapter 5, not only will I examine the features of less and more productive coaching moves in more detail to help illustrate the features of coaching moves that led to a range of productivity, I will do so in ways that seeks to better understand the potential interplay between the various contextual factors that were present and the overall productivity of the work of the coach in different sessions.

Chapter 5

Findings About Range of Productivity and Interplay with Contextual Factors

In Chapter 4, I discussed my analysis and development of codes for the coaching moves across my data and created two definitions of what it meant for coaching to be "productive" during planning and debriefing sessions around mathematics. I found that, not only were coaching moves productive when they led teachers to consider a range of MTT, they were productive when they helped teachers make connections among the three MTT themes as well. As I analyzed my data for evidence of productive coaching moves, it was not always as simple as saying moves were "unproductive" or "productive." Rather, I found that coaching moves as enacted across different cycles represented a range of productivity. In Chapter 5, I use these definitions of productive coaching moves developed in Chapter 4 and a series of examples and vignettes from my data to illustrate this range from less to more productive coaching moves in planning and debrief conversations. Figure 11 helps to illustrate the organization of the chapter and my categorization of a continuum of coaching moves that range from less to more productive.

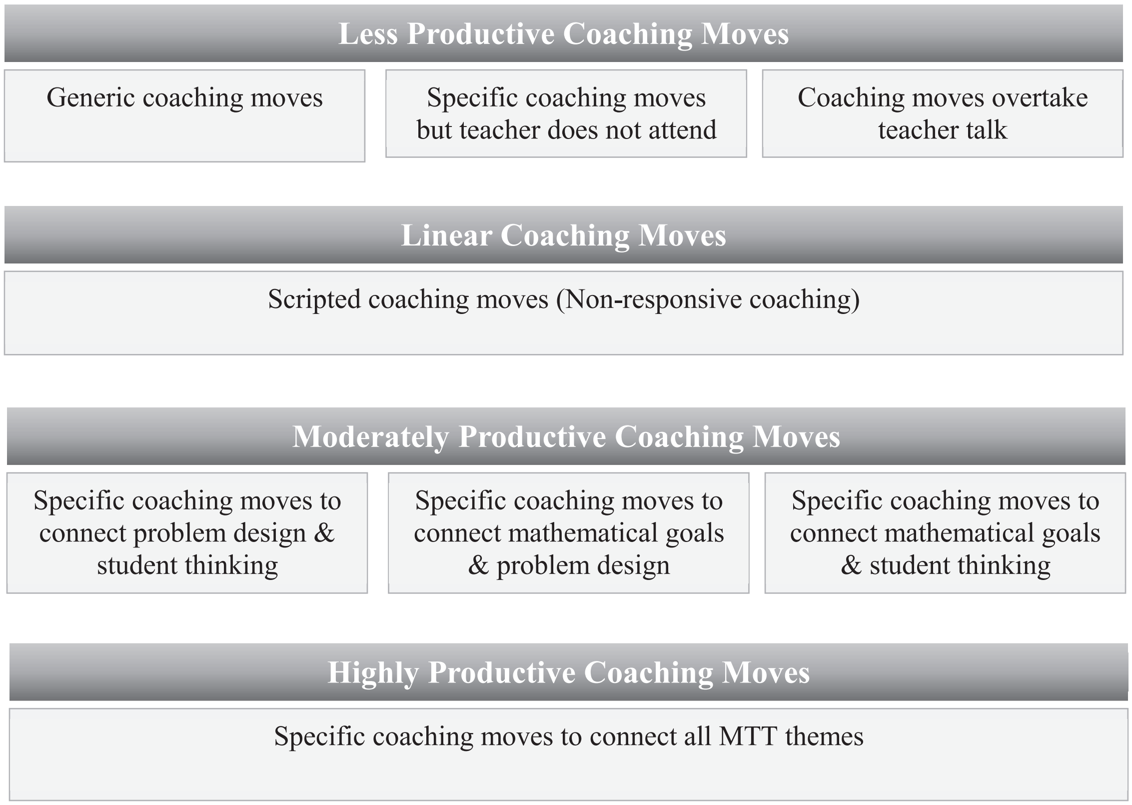

Figure 11. Range of productive coaching moves.

In Chapter 4, I also developed definitions of the types of contextual factors present across these coaching conversations. In this chapter, I further examine the contextual factors present across the range of coaching presented in Figure 11 to better understand how these factors potentially influenced the productivity of coaching conversations. This further addresses my second research sub-question of identifying contextual factors that may positively or negatively influence coaching conversations, and what coaches do, if anything, in response to such factors.

Less Productive Coaching Moves

In the discussion of the current research on mathematics coaching presented in Chapter 2, there was a lack of sufficient literature that model explicit examples of coaching moves that were and were not effective in helping teachers to focus discussion and planning around reform-oriented teaching practice. As I analyzed the coaching moves across my data, I began to focus my attention on certain features of these moves. First, I examined instances of coaching moves I coded as “less productive” across my data. Figure 12 illustrates the three types of coaching moves present in less productive conversations with classroom teachers during planning and debrief sessions. In this section, I offer examples of the types of coaching moves that tended to result in less productive coaching conversations across my data: 1) coaching moves that were more generically worded, 2) coaching moves that were specifically worded around MTT but the teacher did not attend to MTT, and 3) coaching moves that resulted in the coach overtaking any teacher talk during the planning or debriefing sessions.

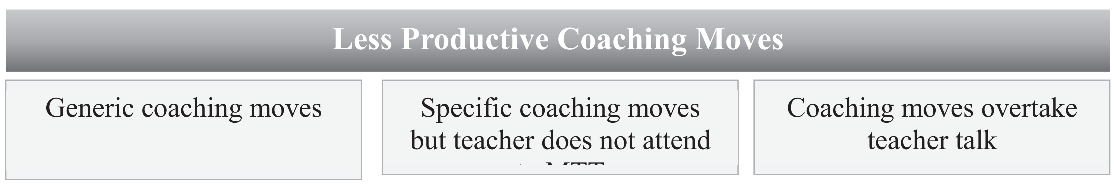

Figure 12. Less productive coaching moves.

The evidence of the least productive coaching moves in my data appeared in conversations where the counts of distinct MTT discussed were lowest (3 or less MTT), particularly when there were few tasks around all three MTT themes. In Chapter 4, Table 9 represented how I coded coaching moves by the type of move used and which MTT theme the move most closely attended to (if any). This table also showed how these moves prompted teachers to talk about MTT. For conversations where counts were the lowest, I examined the coaching moves used and how teachers responded to better understand why these low counts may have occurred.

Table 17 illustrates the coding for both the sequences of coaching moves and teacher responses in these conversations, using the codes from Table 10 (Chapter 4). In Table 17, I also indicate whether the coach used follow up moves to probe further when an initial move did not result in talk about MTT, and whether coaching moves attempted to connect MTT themes.

Table 17

Analysis of Less Productive Coaching Conversations

Coaching Session	Discussion of MTT Themes	Coach Moves & Teacher Responses	M 1	M 2	M 3	M4	M 5	M 6	M 7
Planning 14	3	*Coach Move* [a]	*Q*	*RMG*	*Q*	*SPD* *	*SPS*	*QPS*	*QAS* *
		Teacher Response [b]	PI	PI	SR	SR(G)	G	OL	CD
Debrief 14	3	*Coach Move*	*QPD* +	*QES* *	*QPD*	*QES*	*QAS*		
		Teacher Response	PI, EE	EE	G	CD	__		
Planning 15	2	*Coach Move*	*Q*	*QAS*	*RG*	*QAS*	*SPS, I*		
		Teacher Response	G	EC, T	G	G	SC (G)	SPD	
Debrief 15	1	*Coach Move*	*Q*	*I*	*QAS*	*SES*	*SPS*	*SPS*	
		Teacher Response	G	__	G	G	SC	G	
Planning 9	3	*Coach Move*	*QBS*	*Q*	*QMG*	*SPD* +	*QPD*		
		Teacher Response	G	PI	FE-	G	G		
Debrief 9	3	*Coach Move*	*RMG*	*SET*	*SPD*	*SET*			
		Teacher Response	SR	SC (G)	PI (G)	T			
Planning 8	2	*Coach Move*	*QG*	*SPD*	*QPS*				
		Teacher Response	AQ	AQ	PI				
Planning 4	3	*Coach Move*	*QPD*	*QG*	*SPS*	*QPS*			
		Teacher Response	OL	UN	OL	OL			

[a] Coaching Moves: I = Interruptions; Q = Generic questions; QAS = Questions to anticipate student thinking; QBS = Questions about student background knowledge; QES = Questions about examples of student thinking; QG = Questions about teaching goals; QMG = Questions about mathematical goals;

QPD = Questions about problem design; QPS = Questions about organization and set up; RMG = Restating mathematical goals; SES = Sharing examples of student thinking; SET = Sharing examples of teaching moves/collected data; SPD = Suggestions about problem design; SPS = Suggestions about organization and set up

[b] Teacher Responses: AQ = Productive mathematical questions; CD = Choosing and developing definitions; EC = Evaluating the plausibility of students' claims; EE = Giving/evaluating mathematical explanations; FE = Finding examples to make a mathematical point; G = Generic comments; LR = Linking representations to underlying ideas/representations; OL = Considering organization and logistics; PI = Presenting mathematical ideas; SR = Selecting representations for particular purposes; T = Tangents; UN = Using/critiquing mathematical notation and language

Note : + Includes follow up question or example from coach
* Denotes attempt to connect MTT themes

In examining Table 17, there was evidence that at times coaches did not use coaching moves that kept the conversation focused on the three MTT themes. For example, in both Planning and Debrief 15, the coach's first move (M1) was to ask a generic question (Q). In both instances, the resulting teacher response was also generic in nature (G). In some instances, despite the coach using a move that specifically related to MTT themes, the teacher failed to pick up on these moves and attend to MTT in response. This occurred in Debrief 15 when the coach asked a question about student thinking (QAS), then shared an example of student thinking from the lesson (SES) in coaching moves 3 and 4. Rather than helping the teacher to "evaluate a mathematical explanation" or "evaluate the plausibility of a student's claim," in this instance the teacher response remained generic (G). A third example of a less productive coaching conversation, that the table fails to illustrate, occurred when a coach took over the conversation during the debrief, leading talk about MTT rather than using coaching moves to press the teacher to reflect. In Chapter 2, I examined the need for further research into the types of coaching moves that are necessary to help move teacher thinking around mathematical tasks of teaching and incorporating reform-oriented teaching practices in their instruction. These unproductive instances of coaching moves offer insights into pitfalls that coaches need to avoid in order to do this work effectively. In the following sections, I illustrate several of these unproductive coaching instances to better understand how they came about.

Generic Coaching Moves

As Table 17 illustrates, at times the coaching moves themselves were more generic in nature in less productive conversations. The coach may have posed a generic question about the lesson ("Tell me what you're planning…"), without prompting discussion of the actual mathematical problem design. Other times, questions about goals were not framed in ways that got at explicit mathematical goals for the lesson (e.g. questions about teacher goals, such as incorporating more math talk). In the more productive conversations in my data, these sorts of moves often still led to teacher talk around MTT, but this was often untrue in "less productive" conversations. In less productive conversations, such moves led to non-specific remarks from the teacher, or talk around organizational and logistical issues (such as how to group students or what materials to use) rather than the mathematics. Examples of this occurred in Table 17 during Planning 15, Debrief 15, and Planning 4. Particularly when the coach did not include another question, idea, or suggestion ("follow up" coaching moves) to help nonresponsive teachers connect to MTT themes, these more generic moves failed to move to conversation toward mathematically focused planning. This relates to the patterns of questioning discussed in Chapter 2. When coaches did not use coaching moves in ways that helped teachers to "focus" (Herbel-Eisenmann & Breyfogle, 2005) the conversation around MTT in meaningful ways, the work of the coach remained less productive.

In only two conversations in Table 17 did the coach use a follow up move when the initial one did not generate a specific response (Planning 9 and Debrief 14), and in one of those two instances the follow up move still resulted in a generic response (Planning 9, Move 4 in Table 17). This indicates that sometimes a single coaching move, even with a follow up probe, may have been inadequate to foster more productive conversations around MTT, particularly if the moves were not worded in ways that directly connected to specific MTT. The following excerpt from Debrief 15 demonstrates an example of generic responses to coaching moves. Here the coach attempts in turns 11 and 15 to have the teacher share examples of what she noticed students saying and doing during the lesson.

Although professional resources have suggested that “eliciting and using evidence of student thinking” is a critical reform-based teaching practice (NCTM, 2014), the coaching moves here were still worded somewhat vaguely, not connected to specific MTT as the coach phrases them. Although the teacher responded in turns 12 and 16 to questions about overall noticing and then about a student’s strategy in turn 15, the teacher’s responses were both brief and non-specific. She used phrases like, “…they’re doing good,” without describing what in particular she observed students doing mathematically that was “good,” for example.

Coaching Move 1:

11 Coach: […] What did you notice about the math that they were doing?

12 Teacher: I think they're doing good. I like that when we did that, added that addition problem in, how most of them caught it. And even the ones that were doing subtraction, as soon as you said [something].

Coaching Move 2:

15 Coach: Did you get to see what Aiden did? What did he do on that last one because I thought that was interesting?

16 Teacher: Oh, where he just took each set? The ones, the tens and the hundreds and was adding them?

17 Coach: Did he do that again?

18 Teacher: Well, that was just that last one so I don't know.

(Debrief 15 Transcript)

The coach asked questions that might have helped the teacher reflect on student understanding, but did not word turns 11, 15, or 17 in ways the pressed the teacher to attend to any particular MTT. Turn 17 included a "closed question," (Schuman, Smyth, & Christian, 1979) that only required "yes" or "no" responses from the teacher, and in turns 12 and 16, the teacher's responses remained descriptive rather than analytical around student strategy use. When worded in this way, these coaching moves did not help the teacher to examine the potential underlying understandings and misconceptions of the student as a result ("evaluating explanations" and "determining the plausibility of students' mathematical claims"), and the coach moved on after turn 17 to discuss other topics. The conversation never returned to these issues around student thinking during the debrief. When coaches did not press nonresponsive teachers to focus on MTT with specific follow up coaching moves, the conversations tended not to incorporate as many MTT or connect MTT themes. This rendered them less productive than instances where the coach helped the teacher attend to more MTT.

The planning sessions in Table 17 rarely included coaching moves specific to students' mathematical knowledge and thinking. Teachers tended not to examine student thinking when prompted to consider it during the debrief either, as in Debrief 15. An absence of coaching moves that pressed teachers to analyze the mathematical understanding of students does not align with the professional literature on coaching, which explains the intent of examining data and students' mathematical thinking as a way to inform instructional next steps. Smith and Stein (2011) referred to the idea of "anticipating" student thinking to help teachers plan ways to respond to different student ideas during the lesson. "Evaluating the plausibility of students' claims" (Ball, Thames, & Phelps, 2008) as a mathematical task of teaching to consider during the debrief could help teachers anticipate the strategies students may employ and misconceptions they may have in later lessons. Discussing MTT related to these issues could have helped teachers address future strategy use and struggle by planning and "asking productive mathematical questions" (Ball, Thames, & Phelps, 2008; NCTM, 2014), rather than coming up with responses to student ideas "in the moment" (Stein, Smith, Henningsen, & Silver, 2009). Saphier (2013) argued that focusing planning conversations around content dramatically influences lesson enactment. Helping teachers use debriefs to plan for future teaching can make these conversations connect to teacher practice beyond the scope of the three part cycle.

In the conversations from Table 17, if teacher talk did stay focused on MTT themes, comments were typically brief, often with teachers offering only a few words in response, as in turns 12, 16, and 18 from Debrief 15. Teacher comments also tended to be generic in nature, with comments like, "Oh they did great" (Debrief 9), rather than examining the mathematical thinking of students. Additionally, the coaching moves in these conversations often failed to make connections between the MTT themes, if they addressed each of the three MTT themes at all. In Table 17, instances where coaching moves made a connection between MTT themes were noted with an (*). In examining the shift from one coaching move to the next in these conversations, little attempt was made by coaching moves to help connect talk around problem design and student thinking, or talk around mathematical goals to their influence on lesson design. Not helping teachers make these sorts of connections illustrate missed opportunities on the part of the coach to help teachers recognize and learn to negotiate the "teacher-content-student relationship" that Lampert (2001) discussed in her work as a critical component to learning to teach mathematics in reform-oriented ways that were responsive to student needs.

This was true in all but two brief instances in Planning and Debrief 14. When an attempt at connecting MTT themes was made in this cycle, it was only between the themes of mathematical problem design and student thinking, and never included a tie to mathematical goals. In these coaching conversations, the evidence in my data suggests that the ways in which coaches presented these coaching moves may have led to a lack of productive talk around MTT themes. In both conversations, what the coach said was either too broadly stated, were presented as closed questions, or the move was not followed up with additional questions, ideas, or examples when teachers failed to respond, resulting in a lack of connection-making. This underscores the importance of coaches' use of specifically phrased follow up coaching moves when teachers did not focus on the relevant MTT intended by the initial coaching move for productive conversations to occur.

Specific Coaching Moves but Teacher Does Not Attend to MTT

Another feature of less productive coaching conversations was that even when coaches used coaching moves that were specific to relevant MTT, and even when coaches used follow up moves, there were times the teacher still did not respond with talk around MTT. After multiple attempts of pressing an issue, coaches had to choose whether to continue to direct the conversation or to be more responsive of the direction the teacher was shifting the talk (Ippolito, 2010) to maintain balanced conversation. Sometimes this resulted in moving on despite being unable to generate discussion with the teacher about MTT. In Planning 9, for example, the teacher described a series of unconnected activities as her plan for the coached mathematics lesson in response to the coach's remark, "Let me see what you're planning" (Planning 9 Transcript). The teacher's response included the following activities for the lesson:

- Using the number line to order numbers 1 through 20,
- Use snap cube "sticks" to show groups of ten,
- Modeling counting order on a number line,
- Find the number before/after a given number, and
- Representing teen numbers (Planning 9 Transcript).

It was perhaps unclear from the list, which ranged from ordering numbers, to finding n+1/n-1 numbers, as well as representing numbers, what particular goal the teacher had for the lesson. The coach used a move that was worded specifically around the mathematical goal for the lesson, another productive teaching practice endorsed by the professional literature (NCTM, 2014; Smith & Stein, 2011), by posing an initial question in turn 29 and a follow up question in turn 31 to help the teacher consider what her goal was, and the extent to which students understood.

> 29 Coach: Specifically, what is your objective for this lesson? When you get done, what do you really want to know?
>
> 30 Teacher: I want to know if they can look at a ten frame, recognize the numbers and write that number and then if they know the teen numbers in order. Because I know they know one through ten in order.
>
> 31 Coach: Okay, what, what will be your gauge? How will you decide if they met the objective? What are you thinking? Through your observations with that low group?
>
> 32 Teacher: It's just going to be my observations.
>
> (Planning 9 Transcript)

Although the teacher responds to the final question posed by the coach in turn 31, she did not go into further detail here (or anywhere else in the conversation) what specifically she would look for students to say or do to determine understanding and the extent to which her goals were met during the lesson. It was unclear in the discussion as to how well the teacher believed the activities for the lesson were aligned with the teacher's stated goal in turn 30 of recognizing representations and counting in order (e.g. "selecting representations for a particular purpose" (Ball, Thames, & Phelps, 2008)). The teacher's response in turn 32 was typical of her responses throughout this conversation, in that she made general remarks and did not elaborate, even with further prompting from the coach, to develop a more explicit plan for her lesson goals.

Only in Planning 14 was there much evidence that the coach attempted to move back and forth between MTT themes. In this conversation, at times more generic questions were posed, which may have led to a lack of specificity in the teacher's responses. Often there was a lack of follow up moves from the coach to generate more in depth discussion, and there was a lack of connection-making among MTT themes. This led to superficial and brief conversation around the mathematics. At one point, however, the coach offered a suggestion about adapting the problem design in Move 4 (see Planning 14 in Table 17) based on the teacher's comments that the textbook activity had gone poorly in the past. This may have been intended to help the teacher consider how "presenting mathematical ideas" (Ball, Thames, & Phelps, 2008) could influence student understanding. Turns 27 and 28 illustrate this coaching move and the somewhat generic teacher response.

> 27 Coach: What if, so, if you started out with your story and then you did this and they got it, describe it, what if you after they did this and, I'm thinking because you ask some math talk questions- ask them to describe it and that they engage? Here's the Teach and Talk, what does it look like? What about if you have them find circles in the classroom, would there be an opportunity for them to find a circle in the classroom and bring it up to a circle up front? Or I don't know…
>
> 28 Teacher: That's possible, I don't know a ton of stuff in here that would probably be mobile… They might be able to find a few things maybe.
>
> (Planning 14 Transcript)

In this instance, the coach offered the initial suggestion in turn 27 (Move 4) to adapt the mathematical activity into one that was more hands on and interactive for students. When the teacher's immediate response to this move was somewhat vague in turn 28, the coach continued to flesh out this suggestion in Move 5 with a follow up idea about the setup of the activity, and Move 6 with another question about problem set up. The teacher's response to Moves 5 and 6 focused more on the classroom management around having students up and moving around the room to find circles, rather than keying in on what the coach was trying to do to connect problem design and anticipating students' mathematical thinking (Smith & Stein, 2011). In Move 7 the coach posed a question to help the teacher anticipate a possible mathematical misconception (Smith & Stein, 2011), asking, "Do you think maybe they'll say that's [the ball] is a sphere?" (Planning 14

Transcript). The teacher's response dismissed the idea as a nonissue for the lesson because three-dimensional shapes had not yet been introduced. There was no additional dialogue about how to address the difference between circles and spheres if the situation were to arise during the lesson, and the planning conversation quickly wrapped up after coaching move 7.

Again, despite the coach making multiple attempts to press the teacher to think through the mathematics and adapt the problem design in ways that would benefit student understanding, the teacher did not attend to specific MTT in ways that helped her to make a connection between the two themes. Rather than the teacher discussing MTT related to problem design and anticipating student thinking, she focused on organization and logistics related to the classroom management of the lesson. At the end of this coaching cycle, the coach explained that she had to cut the conversation short because of lunch duty, which may have added to the challenge of finding ways to help the teacher make connections (Interview with coach, Planning 14). Later in this section, I examine the contextual factors that may have influenced the productivity of these coaching conversations in more detail. Such excerpts provide evidence that at times, despite the coach's attempts to promote teacher talk around MTT, teachers did not always pick up on these coaching moves and consider these MTT as a result. Instead, teachers focused at times on logistics and organizational issues related to lesson planning, rather than the mathematics.

Coaching Moves Dominate the Conversation

A third type of unproductive coaching conversation, albeit the least frequent one, developed in my data as well. In Debrief 9, rather than using coaching moves that helped the teacher attend to MTT, the coach "took over," leading all of the discussion and idea sharing around MTT herself, while the teacher remained a passive recipient of information. The teacher did not offer insights around MTT, rather she listened to the coach without adding her own thinking throughout the conversation. In the following excerpt, in turns 7, 13, and 15 the coach leads the talk around MTT. The teacher's responses in turns 9, 10, 12, 14, 16, and 18 are extremely brief replies to the coach's comments and questions.

> 7 Coach: So, when I was in here yesterday I was really honing in and thinking about the questions you were asking and kind of those talk moves we had talked about. So I noticed that you did ask a lot of those higher-level questions we talked about. I just had a couple quotes, and it's for the questions that came up you know, "How do know?" is something you asked students, and, "What do you notice about….?" These are really great questions for eliciting that reasoning and thinking. The questioning was really fantastic and I could tell you were very intentional about it. Are you, is that something…?
>
> 8 Teacher: I typically do, yeah.
>
> 9 Coach: It just comes. So, we had talked about that earlier.
>
> 10 Teacher: Yeah.
>
> 11 Coach: So that's something that you're very comfortable with.
>
> 12 Teacher: Mm hmm.
>
> 13 Coach: Okay. The next part we talked about revoicing, where the teacher repeats the student's reasoning. And so just a couple of examples of what I heard. He was explaining, "There are three dots on top, he said there was two on the bottom. So he knew it was five." So how do you, how does that feel to you?
>
> 14 Teacher: Oh, comfortable.
>
> 15 Coach: So, comfortable, for the most part. I was wondering, I was thinking about that, when the teacher revoices, I was thinking how we could make that a little more impactful on students. What could we do to change that? I am wondering if we were to really get deeper into their reasoning and kind of validate and give them ownership for that thinking. I know that what I first started using talk moves, I would revoice to my class, like, "Hey so and so just said…wow, did you hear that?" I am wondering if you would be comfortable trying, like if P__ says something to me and I just look at P__ and revoice what she said. So I would say, "So P__ what I hear you say is…you know, 'I saw five on top and three on the bottom, and that's how I know it's five." And say, "Is that what you said?" And kind of give her validation for that reasoning and have some ownership there, and then I can either choose to revoice it to the class then, or I can slip in with a, "Who can repeat P__'s great reasoning?"
>
> 16 Teacher: Okay.
>
> 17 Coach: Does that make sense?
>
> 18 Teacher: Uh huh.

(Debrief 9 Transcript)

There is no evidence in this episode of the teacher's thinking or whether she is making connections between the MTT and ideas the coach is presenting because she does not express her opinions out loud. In an instance such as this, where the coach led all the talk around MTT, balance in the conversation was not maintained (Ippolito, 2010). Multiple sources in the coaching literature, including Jim Knight's instructional coaching resources, described the importance of the coaching relationship being a "partnership" (Knight, 2004). When this partnership and balance are not maintained, it is possible the teacher may become non-responsive during the conversation. This is similar to Stigler and Heibert's (1999) findings of teaching that was focused on teacher-led, "teaching by telling" (Smith III, 1996) methods of instruction, which tended not to focus on students' mathematical thinking. When coaches attempted to "coach by telling," these coaching moves were not focused around the teacher's thinking about MTT. If the goal of coaching is to help shift teachers toward considering a range of MTT in their planning and debriefing, then understanding how to engage the teacher in the thinking and planning is critical to developing coaching practice that facilitates productive coaching moves.

Contextual Factors in Less Productive Coaching Conversations

These less productive coaching conversations often included the use of coaching moves that lacked specific ties to MTT, and typically lacked follow up coaching moves when teachers did not attend to MTT after an initial move was made as well. In each of the eight coaching conversations in Table 17, a range of contextual factors were present as well. Figure 13 shows the conversations from Table 17 where I coded evidence of contextual factors during the coaching cycle.

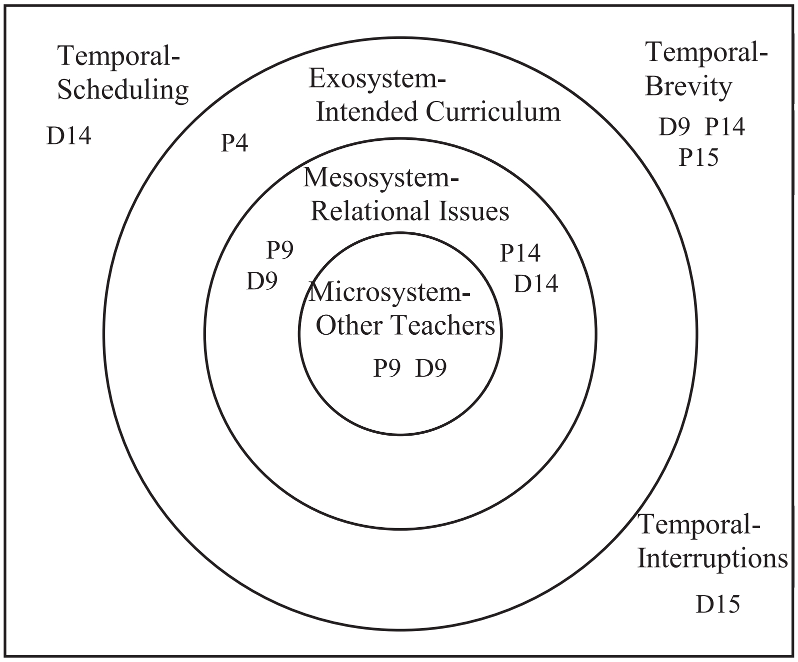

Figure 13. Contextual factors in less productive coaching conversations.
Note: P4= Planning 4; P9= Planning 9; P14= Planning 14; D9= Debrief 9; D14= Debrief 14; D15= Debrief 15

Figure 13 illustrates the factors that were present across less productive coaching conversations. Mesosystemic and temporal factors were the most prevalently coded types of factors across less productive sessions. The mesosystemic factors coded in these planning and debrief sessions involved perceived relational issues between the coach and teacher, which could pose a potentially negative influence on the productivity of the coach's work. The temporal factors were related to issues scheduling a debrief, interruptions that occurred during a debrief, and the brevity of several sessions, which could also be construed as negative influences on the coaching cycles where such factors were present. There was also one coaching cycle with a microsystemic factor (building level individuals and environs that interact with teachers and directly influence the relationship and work with the coach) and one with an exosystemic (broader district and administrative influences) factor.

Microsystemic factors- other teachers. Microsystemic factors are those that stand to directly influence the beliefs and actions of the classroom teacher. Evidence of microsystemic factors were present in Planning and Debrief 9, when the teacher's relationship with her grade level was mentioned as a possible influence on the tenuous mesosystemic relationship between the coach and teacher. Prior to the coaching cycle, the coach shared with me, "It has been difficult to share things with this team, so I've gotten a lot of push back about things…there's kind of one that tells everybody what to do, so if that one doesn't agree with me then it's kind of like, 'Nope, we're done.'" (Interview with coach, Cycle 19). This concern about the influence of other team members may have negatively influenced the coach's work with this teacher, at least from the coach's perspective, as a result. In my one-on-one interview with the coach, she shared,

> I think she acted, her initial actions were open but I have a funny feeling that it was just kind of…the proof will be when I see it. A "see it then believe it" kind of thing. I think that she's willing to have the conversation, she's just going to be a little tougher to get to. To make that shift. But that's kind of the experience I've had with that whole team. (Interview with coach, Cycle 9)

At times, peers can play a role in encouraging and dissuading teachers from collaborating with others. Sometimes shared beliefs can produce a "rigidity about practice" (McLaughlin, 1993, p. 95) and create resistance to instructional change. If a teacher's grade level team was reluctant to work with a coach, it is possible that such reluctance may also have translated to individual coaching relationships. As the classroom teacher from this coaching cycle was unwilling to be interviewed at the end of the semester in order to gain her perspective, this microsystemic factor is evidenced solely by the coach's perception in my data.

Mesosystemic factors- relational issues. Mesosystemic factors are those that directly relate to the relationship between the coach and a classroom teacher. Perceptions of relational factors between the coach and teacher were present in some of the less productive coaching cycles in this section. As Figure 13 illustrates, both the planning and debrief for cycles 9 and 14 showed evidence of mesosystemic factors present that may have influenced these conversations. One coach explained,

> It goes okay, but it's different than the other coaching cycles in that I feel like [the teacher]'s open to anything, but it's not so much a reflection, a reflective piece of it, it's just like, it's almost like [the teacher] wants me to tell them what I want them to do and then they'll say, "Uh, well that kind of worked, but I really don't want to," it's not, there's not a buy into it as much, I think. (Interview with coach, Cycle 15)

Similarly, in the instance of Planning 9, the coach shared that it was her first time working with the teacher in a coaching cycle, and she was uncertain what to expect. The coach reflected, "When I have been in there, sometimes I just pop in there during her math block so I could just see what was happening, and I could feel that she changes when someone walks in. Like I can feel that defensiveness sometimes, so I try to be very careful when I work with her" (Interview with coach, Cycle 9). The coach went on to say that she was uncertain as to the extent that the teacher understood the goal of coaching cycles, or of the role that the coach typically plays during this type of coaching.

It is possible that there was a lack of developed mesosystem between the coach and teacher at the time of my data collection, based on the coach's insights during the pre-observation interview in Cycle 9 that the process was new and both the coach and teacher seemed uncertain as to the expectations of one another throughout the coaching cycle. This suggests that a lack of understanding on the part of the teacher as to the purpose of the coach's visits, along with a lack of relational trust between the two, could potentially have had a negative influence on the productivity of the coaching interactions. The literature on working with teachers who are unfamiliar with the coaching process that was presented in Chapter 2 suggests that coaches must move teachers from their current understanding of what it means to work with a coach (West, 2008; Knight, 2007), and differentiate their coaching practice (Kise, 2006) in ways that support teachers who are unfamiliar with this work. In these less productive instances of coaching, the lack of a strong, functioning relationship between the coach and teacher, coupled with a lack of productive coaching moves tended to result in less productive planning and debriefing sessions with these teachers.

Exosystemic factors- the intended curriculum. Exosystemic factors are the broader factors that may impact coaching less directly, and typically include influences from the district or administrative level. There was only one instance of an exosystemic factor in the data set presented in Figure 13. In Planning 4, the novice teacher with whom the coach met was launching a new chapter in math. The setup of the district pacing allowed one day for giving a pre-assessment and introducing academic vocabulary terms for the chapter. During the observed coaching cycle, this sort of introductory lesson was the focus of Planning 4. The coach explained to me in her interview that the teacher was still new to teaching, and typically wanted to focus on topics such as pacing, engagement, and classroom management (Interview with coach, Cycle 4). As an introductory lesson, the coached content did not investigate a particular mathematical concept. Prior to the planning session, the coach reflected,

> …I don't [have a coaching focus] because to be honest the lesson that she sent me is the opener for the chapter, so it isn't necessarily the best coaching lesson per say. So we'll see what she wants to work on. She does want to work on centers and getting to those rotations, so we'll see, like maybe I can push that today. (Interview with coach, Cycle 4)

In this instance, since it was the chapter introduction, it is possible that the "intended curriculum" (Porter, 2006) provided less opportunities to discuss a wide range of MTT with much depth. The teacher's focus was on the chapter vocabulary, and coaching moves tended to focus on engagement and the time management needed to include small group work at the end of the lesson as a result.

Temporal factors- scheduling, brevity, and interruptions. Three types of temporal factors were present in the coaching conversations presented in Figure 13. In several instances, extra duties were cited as reasons to cut conversations short. One coach explained that she was responsible for bus duty before and after school, as well as lunch supervision (Interview with coach, Cycle 4). During Debrief 14, the coach ended the conversation after 12 minutes, stating, "And I hate to run, but I've got to make sure to get to lunch duty on time" (Debrief 14 Transcript). Scheduling was not always cited as an issue in other sessions. Debrief 9, Planning 14, and Planning 15 were all brief conversations (see Tables 7 and 8 in Chapter 4), yet these instances offered no evidence to support specific reasons for the brevity. Debrief 15 included two brief interruptions, one by another teacher and one by intercom announcements. In that instance, the coach attempted to maintain a focus on MTT despite the interruptions, and it is unclear that this factor changed the course of the conversation in any way.

As well as length of the conversation, the amount of time that passed between the three parts of the coaching cycle also varied. In Debrief 15, a longer than usual amount of time passed between the lesson and debrief due to parent-teacher conferences. As the coach and I discussed some of her decision-making after the debrief, she expressed frustration about the challenge of working around this temporal factor with this particular teacher.

> 15 Interviewer: It could be a misunderstanding that the kids could have. So do you think [the teacher] picked up on that or…?
>
> 16 Coach: I don't know and we didn't talk about that either.
>
> 17 Interviewer: I know that the debrief was kind of so many days after that I wasn't sure which part, I actually jotted some notes down of things I wanted to be sure to look for in the debrief and then ask about afterwards, just kind of, did you do that?
>
> 18 Coach: I totally forgot about that. I totally forgot. Now I wish I would have. I don't know if he did because that's one is that's one where when I have a relationship where the teachers are more reflective, that I think like [another teacher] would have picked up on that, but I don't think [the teacher] did and I wish I would have asked that, but I totally forgot. I totally forgot about that.
>
> (Interview with coach, Cycle 15)

Since I referred back to my field notes from the planning and lesson when talking with the coach, certain features of the coaching cycle may have appeared clearer in my mind than in hers at the time of the interview. In turn 18, the coach expressed frustration at a missed opportunity to help the teacher to reflect, citing perceived features of this coaching conversation as to why this time lapse may have been more impactful in this instance than her work with some other teachers.

The examples of coaching conversations in this section illustrate ways in which contextual factors can influence planning and debriefing sessions between coaches and teachers. In these instances, contextual factors that could be considered as potentially negative were present in conjunction with less productive coaching moves. Taken together, the data presented a range of reasons that could have led to less productive coaching. Recognizing the existence and potential influence of these contextual factors on the productivity of coaching moves and planning and debriefing sessions could help mathematics coaches become more cognizant of the ways in which these factors may interact with coaching sessions to develop coaching practices that are productive in spite of these influences. Factors such as microsystems between other teachers and the coached teacher, the exosystemic issues of the intended curriculum, and a range of temporal challenges (scheduling, brevity of conversations, and interruptions) can influence the ways in which coaches are able to engage teachers in conversation around MTT. To mitigate such factors, coaches must recognize what it looks like when coaches *can* productively implement productive coaching moves despite the presence of negative factors. Upcoming sections in his chapter seek to further address this work of the coach and what it looks like to overcome contextual factors with productive coaching moves to engage teachers in conversation around MTT and make connections between MTT themes.

Linear Coaching Moves

The second categorization of less productive coaching moves I developed during my data analysis were coaching moves that I described as "linear," illustrated in Figure 14.

Linear Coaching Moves
Scripted coaching moves (Non-responsive coaching)

Figure 14. Linear coaching moves.

There were several conversations in my data where coaching moves attempted to focus talk around MTT, yet often these moves did not result in talk around many MTT, or failed to make connections between MTT themes. Although some of these conversations were classified as "less productive" due to limitations on the part of the coach or the teacher to engage in a balanced and meaningful discussion of MTT, there were a few conversations that stood out from the rest.

In four instances, the pattern of the coaching moves suggests that a somewhat linear nature of the progression of coaching moves in these conversations may have impacted the productivity of how these moves played out across these planning and debrief sessions. In these examples, the coaching moves tended to shift through MTT topics separately, rather than helping teachers make connections between the MTT themes. In these "linear" conversations, teachers typically attended to coaching moves with less generic responses and attended to more MTT (unlike those conversations that I categorized as "less productive"), however many of the comments made by teachers were still brief in nature. Since coaches often shifted from talking about one MTT theme to another without circling back or pressing the teacher to elaborate, oftentimes the teachers did not address individual MTT deeply or make connections between the MTT themes throughout the conversation. In a sense, the coach was less responsive during the conversation in ways that could have helped teachers make these connections.

Scripted Coaching Moves (Non-Responsive Coaching)

In coaching conversations that tended to be more linear, an examination of the coaching moves and resulting teacher responses in further detail illustrated what these disconnected conversations looked like in practice. Table 18 presents the coaching conversations I coded as "linear," and provides a look at the presentation of coaching moves, as well as the teacher responses, again using the coding key presented in Table 10 (Chapter 4). In examining the moves as they played out chronologically within these conversations, there were several things to note. First, if coaching moves focused on mathematical goals were present, they were typically referenced only once, with exception of Planning 1 and Debrief 18, where two questions in a row were posed around goals. Most often, these conversations included coaching moves focused around student thinking and problem design. Although coaching moves around mathematical goals were used more frequently by coaches in these conversations than in those presented earlier in Table 17, this MTT theme was still addressed much less frequently than the other two themes in linear talks.

Table 18

Analysis of Linear Coaching Moves in Coaching Conversations

Coaching Session	Tasks in Themes	Move & Response	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9
Planning 7	5	*Coach Move* [a]	*QBS*	*QBS* +	*Q*	*SMG SPD* +	*QPS*	*RMG*	*SPD*	*SPD*	*SPD*
		Teacher Response [b]	SC, PI	SC	OL	G	PI	LR	AQ	PI, OL	OL
Debrief 7	4	*Coach Move*	*SES*	*QPS*	*QPD*	*SET*	*I*	*SET*	*SES*	*QES*	*QMG* *
		Teacher Response	G	OL	SC	LR		AQ	SC	SC	LR
Debrief 10	4	*Coach Move*	*QES*	*QMG*	*QAS* +	*QES* +	*QPD* +	*Q*	*QBS**	*QES*	
		Teacher Response	EE	G	SC	LR	G	OL	G, PI	SC	
Planning 18	4	*Coach Move*	*QMG*	*Q*	*QAS*	*QBS*	*QAS*	*QPS*			
		Teacher Response	SR, PI	OL	G	LR	SC	OL			
Debrief 18	2	*Coach Move*	*Q*	*RMG*	*QMG* +	*QPD*	*SES*	*Q*	*SPD* +	*SES*	
		Teacher Response	SC	SC	G	PI	PI	CD	G	G	
Planning 19	4	*Coach Move*	*QBS*	*QAS*	*QPS*	*QPS*	*SPD*	*QPS*	*QAS*	*I*	*QPD*
		Teacher Response	CT, RR	SC	EE	AA, OL	G	OL	G	__	UN

[a] Coach Move: I = Interruption to conversation; Q = Posing generic questions about the lesson; QAS = Posing questions to anticipate student mathematical thinking/strategies; QBS = Posing questions about student background knowledge of mathematics; QES = Posing questions about examples of student mathematical thinking/strategies; QMG = Posing questions about mathematical goals; QPD = Posing questions about mathematical problem design; QPS = Posing questions about the organization and set up of the problem/activity; RMG = Restating mathematical goals; SES = Sharing examples of student mathematical thinking/strategies; SET = Sharing examples of teaching moves/collected data from lesson; SPD = Offering suggestions about mathematical problem design

[b] Teacher Response: AA = appraising and adapting the mathematical content of textbooks; AQ = Asking productive mathematical questions; CD = Choosing and developing useable definitions; CT = Connecting a topic being taught to topics from previous or future years; EE = Giving or evaluating mathematical explanations; G = Generic comments; LR = Linking representations to underlying ideas and other representations; OL = Considering organization and logistics; PI = Presenting mathematical ideas; RR = Recognizing what is involved in using a particular representation; SR = Selecting representations for particular purposes; UN = Using mathematical notation and language and critiquing its use

Note : + Includes follow up question or example from coach
* Denotes attempt to connect multiple MTT Themes

Typically, in linear conversations, the coach began by talking about student thinking, then shifted to coaching moves around problem design. If the focus returned to an already mentioned MTT theme, it was most often to move from coaching moves around problem design to student thinking, as in Debriefs 2, 10, and 18. The coaching moves in the conversations in Table 18 seldom made connections among MTT themes. In Debrief 7 and Debrief 10, the coach used one coaching move to make such a connection. This was an uncommon occurrence within linear coaching conversations. More typically, coaching moves focused on one MTT theme, then shifted to another, without much interaction among these themes throughout the conversation.

It was typical in these linear conversations for the coach to lead off with coaching moves that were centered on students' mathematical thinking, then shift toward moves that focused around either the problem design or organization and set up of the lesson, then shift back toward student thinking near the end. Figure 15 illustrates an example of these coaching moves as they played out chronologically during Planning 7, moving across a list of topics from background knowledge to mathematical goals to problem design as the conversation unfolded.

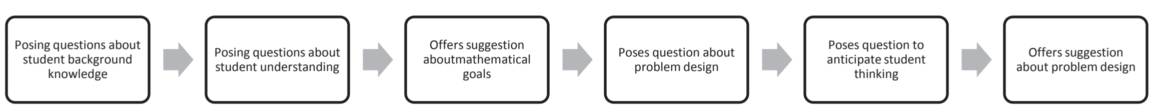

Figure 15. Example of linear coaching moves (Adapted from Planning 7 Transcript).

Despite addressing student thinking at more than one point during the conversation, the coach did not connect talk around students' background knowledge to the mathematical goals of the lesson. Even though later in the conversation the coach circled back to anticipating student thinking, the teacher was the one to make the shift, not a coaching move. The coach's focus was more on moving through the topics, and was only responsive when the teacher changed the overarching topic, rather than using coaching moves to link these MTT themes together.

Typically, coaching moves around the three MTT themes played out in isolation from one another during the conversations in Table 18. For example, in Table 19 I share an excerpt from Debrief 18 where the coach shifted from reflecting about mathematical goals to considering aspects of problem design, without attempting to bridge the two themes together. Doing so might have provoked the teacher to consider how the extent to which her goals were met might influence ways she would consider adapting the problem design. Table 19 illustrates how the phrasing of these two coaching moves do not press the teacher to consider how these themes of mathematical goals and problem design could interact with one another in ways to help her consider "next steps" for future planning and problem design.

Table 19
Example of Disconnected Linear Coaching Moves from Debrief 18

Coaching Move	How the Question is Posed
Move 3: Posing a question about mathematical goals	So I mean, you have lots of, lots of different little activities that happened during the time. Um, did you feel like they met your expected outcomes?
Move 4: Posing a question about adapting problem design	Is there anything you would do differently? Anything that you felt you would change as far as the lesson goes?

If the coach had phrased coaching move 4 slightly differently, for example asking the teacher what she might do differently in light of her reflection on the extent to which she felt students met the lesson goal (coaching move 3), a follow up move could have helped her to consider how this tied to future planning. NCTM (2014) described the importance of establishing clear goals, and using these goals and knowledge of students' understanding related to these goals, as a productive mathematical teaching practice, and Saphier (2013) explained that it is critical to determine what is most worthwhile and most confusing in the content in order to plan effective "next steps" instructionally.

This lack of connection making from student understanding to future planning was a common occurrence in the debrief conversations that I categorized as linear. Although student thinking was often a focus in these debriefs, the coaching moves failed to help teachers connect this MTT theme in ways that might directly and immediately influence future teaching practice, similarly to the less productive debriefs in the previous section. In the few instances where teachers did share thinking along these lines, it was more about *when* in an upcoming lesson they might address lingering concerns, rather than talk about *how* to go about doing this. This contrasts with examples of more productive coaching conversations that I share later in Chapter 5, where coaching moves use conversation around and evidence of student thinking to inform planning. These linear sequences of coaching moves consisted of discussions around the mathematics that were often brief and less connected than conversations that contained more connected coaching moves around the MTT themes in my data.

Contextual Factors in Linear Coaching Conversations

In the data collected around these linear conversations, there was limited direct evidence offered by coaches as to the contextual factors that may have influenced the patterns of coaching moves in these instances. As I examined the coaching conversation transcripts, interviews with coaches, and my field notes, a number of factors surfaced.

Figure 16 shows the linear conversations and the evidence of contextual factors in these planning and debrief sessions.

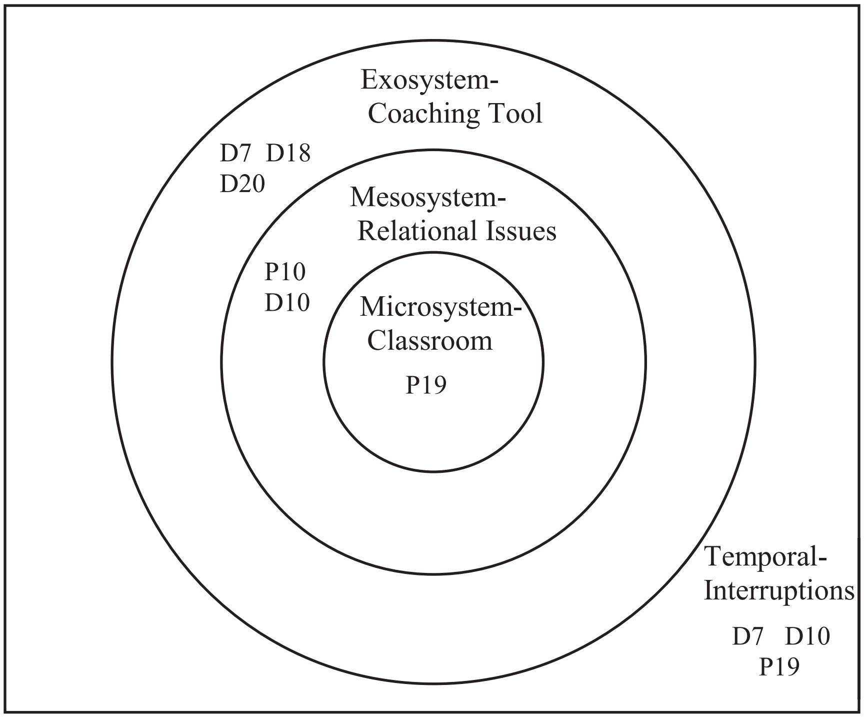

Figure 16. Contextual factors in linear coaching conversations.

Note: P10= Planning 10; P19= Planning 19; D7= Debrief 7; D10= Debrief 10; D18= Debrief 18; D20= Debrief 20

Microsystemic factors- the classroom. There was only one conversation with evidence of a microsystemic factor in Planning 19 where the coach expressed that she found planning with the teacher more challenging that year than the previous one due to issues with student behaviors (the classroom as a microsystemic influence on the teacher's work with the coach). In her one-on-one interview, the coach shared with me that the teacher appeared more reluctant to discuss certain ideas during planning, perhaps in response to these classroom challenges. According to the coach, "I did not realize that our coaching roles would be very different because of her class…we tend to focus on how can we get manipulative use and engagement and not have it digress. A lot of it is management this year" (Interview with coach, Cycle 19). It is unclear that this factor was connected in any way to the linear nature of the conversation in this instance, and no other microsystemic factors were evident in the coaching conversations from Figure 15 to compare. In the remaining conversations, mesosystemic factors were still present, although less frequently than in less productive conversations, and only one type of exosystemic and temporal factor were present.

Mesosystemic factors- new coaching relationships with teachers. The coaches reported to me during their pre-observation interviews that they felt these were teachers who were open to working with them, and in all but one instance who worked with the coach on a somewhat regular basis. This may have resulted in mesosystemic factors being more positive in linear coaching conversations than in less productive coaching conversations. Planning and Debrief 10 were the exception to this, as the coach shared with me that she typically interacted with the teacher's grade level as a group, but this was the first formal coaching cycle she had done with the teacher. As we discussed the cycle after the debrief, the coach reflected,

> …I'd been in her room often, I've modeled a couple things, I brought her some things, and I worked with her team so it wasn't as brand new…so, I think it went okay but…I was looking at my paper like, you know I really didn't set a focus. So, I'm thinking about those things. Like, what exactly are we supposed to be doing? I need to narrow it down… and I'm trying to still read people, kind of figure out exactly what you can and can't, and what they want and don't want. (Interview with coach, Cycle 10)

In this instance, the coach appeared uncertain as to the extent she should push the teacher in this first coaching cycle, even though she had a pre-existing and positive relationship with the teacher and her grade level team. It was beyond my data to know whether this perceived mesosystemic factor of a newer coaching relationship with a teacher influenced the patterns of coaching moves in this instance, but the coach's perspective indicated a lack of certainty in this new adaptation of their coach-teacher relationship, similarly to the new coaching relationships in less productive cycles.

Exosystemic factors- organizational tools. A somewhat unique contextual factor that may have influenced some of these linear conversations was the organizational tool coaches used to help facilitate the conversation. Although this is more of an external factor than a direct influence on the coach-teacher relationship like the previous examples of factors in this section, my analysis suggested that in some instances, these tools may have led to the enactment of more linear coaching moves. In several of the coaching conversations in Figure 16, coaches referred to coach-created documents they used to help guide conversation with teachers. In Debrief 7, the coach shared a copy of her document with the teacher, explaining, "This helps me guide our discussion, and I typed it up for you. It may not make a lot of sense, but there are some points I want to talk to you about" (Debrief 7 Transcript). In my field notes I wrote, "The coach shared a typed form where she has three columns of data recorded: Teaching (the moves the teacher makes), Learning (what students are saying and doing), and Environment" (Debrief 7 Field Notes) I similarly made note that, throughout the debrief, the coach moved through the document, referring to the items in order and without making connections between them during the conversation. Although the coach may have assumed that using an organized tool would help her to focus the conversation around a range of teaching elements, in this instance, an overreliance on the tool may have hindered the coach's ability to be responsive (Ippolito, 2010) to in-the-moment opportunities to make connections between MTT themes.

Similarly, the coach in Planning 18 referred to a coach-generated list of questions she used to guide the conversation, stating, "Alright so I've got some kind of questions that I go through just too, and you've really already hit a lot of them" (Planning 18 Transcript). This comment alluded to the idea of this questioning guide as a sort of checklist, with items to be marked off, rather than viewing the themes brought to light by individual questions as interconnected. It is possible that such documents, if followed without deviation, could have influenced the linear nature of the coaching moves as they played out. In the two instances illustrated here, this is particularly possible when my field notes and the transcript excerpts indicated that the organization of questions on the tool and the lack of deviation from the order the coach presented these elements from the tool may have led to nonresponsive coaching moves (Ippolito, 2010). The planning protocol one of the coaches used with her teachers was organized in the following way:

- What are the big ideas of the lesson?
- What is your primary goal for the lesson
- What prior knowledge do students have? What might be difficult for them?
- Tell me about your plan for the lesson
- What aspects of your instruction would you like me to focus on?
- Is there any part of the problem you would like me to step in? (Planning 18 Field Notes)

Much like the patterns visible in Table 18, the questions from this list either tended to be posed in broad terms that might not have helped teachers attend to MTT themes, or promoted moving through the themes in a disconnected manner. This list of questions moved from focusing on big ideas and goals, to asking about student background knowledge and anticipating struggle, and then asking the teacher to discuss the problem design for the lesson discretely. The design of this question list itself was not such that it led the coach to interweave talk among all three MTT themes, although it did offer ways to address all three themes separately.

Such coaching tools can be useful in helping coaches remember the range of MTT that might be relevant to consider during the planning and debrief, however they also have the potential to be restricting if followed without some flexibility in their use. When considering what it is about coaching moves that makes them more or less effective, it is important to understand this potential pitfall of utilizing external resources to guide coaching conversations. This overreliance on a tool designed to help guide the coaching conversation is similar to some of the research on scripted curriculum in teaching. Much of the literature on scripted curriculum cautions that it can stifle the creativity and innovations of teachers when there is an overreliance on the script at the expense of being responsive to student needs (Ede, 2006; Milsovic, 2007). Reeves (2010) offered the insight that these resources can provide a sort of external expertise for teachers to work from initially, however the goal should be internalization of ideas from the tool so that the resource is used flexibly. In a study on the effects of using a scripted literacy curriculum Parks and Bridges-Rhoads (2012) found that not only did overreliance on the script made it less likely for teachers to innovate or attend to the thinking of students to adjust their mathematics instruction. Similarly, it seems important that coaches must be responsive in using tools and resources in their work with classroom teachers to make connections between MTT themes evident. These tools may be helpful in giving coaches a guiding framework as they plan and debrief with teachers, but like scripted curriculum, coaches must learn to internalize the ideas from the tool in order to be flexible and responsive to the conversation with a particular teacher.

Much like the less productive coaching conversations, linear conversations presented a range of contextual factors in my data, including the microsystemic influence of classrooms, the mesosystemic challenge of new coach-teacher relationships, and the exosystemic factor of coaching tools. Although it was beyond the scope of my data to determine whether these factors definitively influenced the productivity of these conversations, they illustrated the sorts of issues that coaches must be aware of and respond to in their work. Since coaching conversations often include such contextual factors, understanding what it looks like for coaching moves to play out more productively in the presence of these factors can hold key insights then as to how coaches can work meaningfully within these contexts with teachers to plan and teach mathematics. The last two sections of this chapter address the more productive coaching conversations in my data to better understand what this looks like in practice.

Moderately Productive Coaching Moves

In the previous sections, I examined 15 of the 49 coaching conversations in my data where coaching moves played out less productively in helping teachers attend to MTT. These conversations addressed less MTT around the three MTT themes, and almost never included connections between themes. These findings present a partial answer to the lingering gap in the existing literature in Chapter 2 with regards to the types of coaching moves that are more and less effective in helping teachers consider topics related to reform-oriented teaching practices by offering examples of coaching moves that were less effective. The remaining 34 coaching conversations I categorized as “more productive,” as the coaching moves in these talks nearly always resulted in teachers attending to all three MTT themes. Additionally, many of these examples had one or more coaching moves that made links *among* MTT themes, which is illustrated by Figure 17 in my categorization of “moderately productive” coaching moves. Examining this more productive work of the coach can help to more fully address the unanswered questions from Chapter 2.

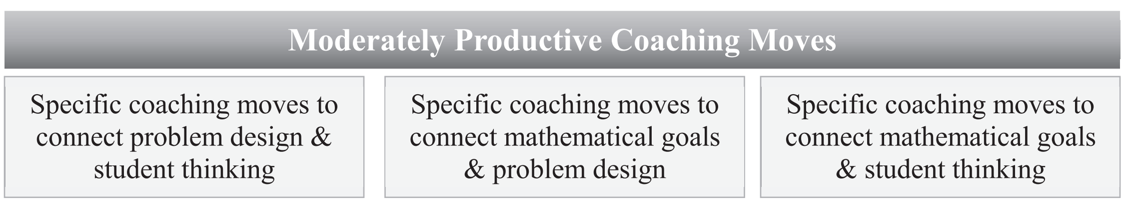

Figure 17. Moderately productive coaching moves.

In Chapter 4, Table 11 illustrated that while 13 coaching conversations did not make any links, 16 conversations had coaching moves that made one MTT link between themes, and 16 conversations had coaching moves that made two links. Coaching moves in only four conversations made links among all three MTT themes. I created Figure 18 to better illustrate the interaction between productive coaching moves that led to teachers discussing a wider range of MTT, and instances where coaching moves made links between and among these themes. The left arrow indicates that as conversations moved up column two they contained lower counts of MTT, and the right arrow indicates that as conversations moved down column four the number of link types made among the three MTT themes increased.

Figure 18 helps to illustrate the patterns of coaching interactions that emerged in more productive coaching sessions with classroom teachers. As the number of MTT that coaching moves helped teachers attend to increased, and as those moves included ones that helped teachers to make connections between and among the three MTT themes, the overall conversations tended to have more depth and teacher responses were specific and tied directly to the mathematics of the lesson, as I will illustrate in this and the final section of this chapter. Debrief 3 illustrates that even when the coach and teacher could not meet face to face, it was possible through the use of specifically worded coaching moves to engage the teacher in dialogue about MTT in ways that helped the teacher see connections between two of the MTT themes.

Less Coaching Moves Around MTT Themes

Coaching Conversation	Count of MTT Discussed in 3 Themes	Duration of Conversation	Count of Links between MTT Themes
Debrief 20	2	no audio	1
Debrief 3	3	email	1
Debrief 23	3	14:59	1
Debrief 5	3	20:25	1
Debrief 17	3	27:27	1
Debrief 21	4	33:31	1
Debrief 11	5	16:17	1
Planning 5	5	28:59	1
Debrief 16	5	32:16	1
Planning 17	6	24:27	1
Planning 26	6	28:07	1
Planning 27	6	39:01	1
Planning 12	7	17:03	1
Planning 11	7	28:48	1
Debrief 13	3	7:01	2
Debrief 22	3	11:11	2
Debrief 12	3	19:03	2
Debrief 26	4	21:05	2
Planning 22	4	22:11	2
Debrief 27	4	24:30	2
Debrief 25	4	29:11	2
Planning 3	4	31:01	2
Planning 20	4	33:20	2
Planning 13	5	10:21	2
Planning 24	5	24:52	2
Debrief 1	5	27:57	2
Planning 21	6	35:21	2
Planning 25	6	39:57	2
Planning 16	7	36:50	2
Planning 1	8	25:16	2
Debrief 24	4	32:16	3
Planning 23	5	28:59	3
Debrief 2	7	13:05	3
Planning 2	7	28:46	3

More Links Among MTT Themes

Figure 18. Interactions between counts of coaching moves around MTT themes and count of link types made *among* MTT themes.

Figure 18 illustrates the range of productivity in coaching conversations across the 34 more productive conversations in my data. In organizing the data for Figure 18, I first ordered conversations by the how many links among MTT themes occurred. Within each range of links, I then organized the data from least to greatest counts of MTT discussed from within those three themes in a conversation. Thus, the lesser productive coaching conversations, in terms of both the range of MTT that coaching moves led to teachers discussing *and* the number of links among MTT themes that coaching moves made, are closer to the top of the figure, while the most productive coaching conversations based on these interactions are near the bottom.

Figure 18 does not offer a complete picture as to coaching productivity. There are contextual factors that may have influenced the ways in which these conversations were enacted, and the at times the counts alone cannot account for the extent to which a coaching move got a teacher talking about particular MTT or made links between MTT themes. Figure 18 is merely an illustration of the tendency for coaching conversations to become more productive as the interaction between these two definitions of productive increased. In the remaining sections of this chapter, I examine these more productive coaching conversations, beginning with conversations that fostered individual links between MTT themes, and ending with an example where links were made among all MTT themes. Within each section, I present examples that illustrate the coaching moves used to make these connections. I also discuss the contextual factors present in more productive conversations.

Specific Coaching Moves to Connect Problem Design and Student Thinking

Coaching moves attempting to connect problem design and student thinking were by far the most prevalent links between MTT themes in my data, with 32 of the 34 “more productive” conversations containing at least one coaching move that made this link. In fact, when only one link was made through coaching moves, it was nearly always between problem design and student thinking. Figure 19 illustrates this link and the ways in which it was made by coaching moves in “more productive” coaching conversations with teachers.

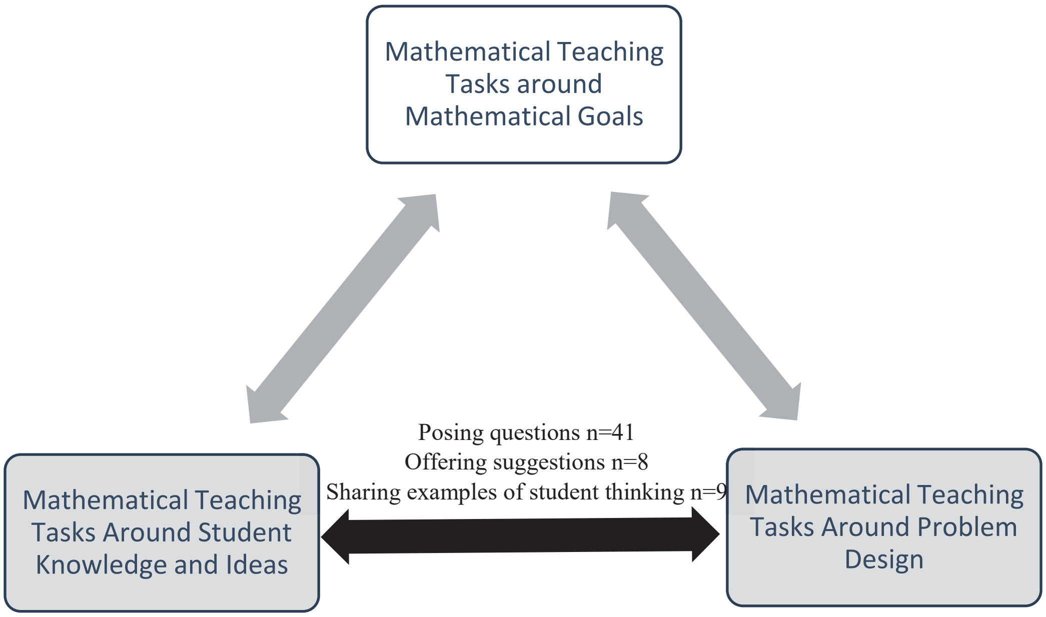

Figure 19. Types and counts of coaching moves to connect problem design and student thinking.

In considering Lampert’s model of the “teacher-student-content relationship” (Figure 8 in Chapter 4), helping the teacher make connections between the content and the students who must learn the content (as Figure 19 illustrates) was a reasonable connection to stand out in my data. The purpose of coaching conversations is to help teachers plan mathematics lessons, which may naturally lead to discussion of MTT around problem design, and several of the generalized coaching moves (Campbell, Ellington, Haver, & Inge, 2013; West & Cameron, 2013), as well as more specific moves, like “anticipating” (Smith & Stein, 2011), are aimed at considering students’ knowledge before, during, and after the lesson to inform problem design.

I revisited my codes for coaching moves around MTT themes in Table 10 (Chapter 4), examining instances of moves that made links between problem design and student thinking to better understand these coaching moves at work. Figure 19 shows both the coaching moves used across more productive coaching conversations that linked problem design and student thinking. Coaches asked questions to make this link a total of 41 times in conversations that I categorized as more productive. During planning sessions, coaches often posed questions asking teachers to anticipate what students might do mathematically, as well as what they might struggle with, based on the problem design for the lesson. In debriefs, the questioning pattern was often reversed. Coaches used examples of student thinking or asked questions about what teachers noticed about students' mathematical understanding and strategy use ("evaluating mathematical explanations," "evaluating students' claims," and "recognizing what is involved in using a particular representation" [Ball, Thames, & Phelps, 2008]) to help them connect aspects of problem design and potential "next steps" for future planning based on this evidence. Additionally, coaches used the move of sharing examples of student thinking to prompt reflection nine times in the data, and offered suggestions about problem design based on student understanding eight times. These moves, although used much less frequently than posing questions, are fairly well represented in making these MTT theme connection, therefore I share examples of all three types of coaching move in this section to better illustrate this work.

Table 20 offers five coded examples of coaching conversations that made links between problem design and student thinking (refer to Table 10 in Chapter 4 for the full coding key). To help focus on coaching moves that helped teachers make these connections, the table includes coded excerpts from the larger conversation rather than coaching moves from the entire talk.

Table 20

Examples of Coaching Conversation Excerpts Where Links Between Problem Design and Student Thinking Occur

Coaching Session	Coach Moves & Teacher Responses	M 1	M 2	M 3	M4	M 5	M 6
Debrief 5	*Coach Move* [a]	*QPD**	*QPD+*	*QPD+*			
(Posing Questions)	Teacher Response [b]	EE, RR	PI, LR	PI, AQ			
Planning 16	*Coaching Move*	*QBS*	*QBS+*	*QPD*	*SPD*+*	*QPD+*	*QAS+**
(Posing Questions)	Teacher Response	EE	LR	OL	PI	PI	EE
Planning 24	*Coaching Move*	*QPD*	*SES+*	*QPD+**			
(Sharing Examples)	Teacher Response	G	EC	PI			
Planning 1	*Coaching Move*	*QAS*	*RMG+**	*QPD+*	*SPD+*	*QPD+*	
(Offering Suggestion)	Teacher Response	PI	EE	PI	RR	AA	
Planning 22	*Coaching Move*	*SPD**	*QAS+*				
(Offering Suggestion)	Teacher Response	EC	EE				

[a] Coach Move: QAS = Posing questions to anticipate student mathematical thinking/strategies; QBS = Posing questions about student background knowledge of mathematics; QPD = Posing questions about mathematical problem design; RMG = Restating mathematical goals; SES = Sharing examples of student mathematical thinking/strategies; SPD = Offering suggestions about mathematical problem design

[b] Teacher Response: AA = appraising and adapting the mathematical content of textbooks; EC = Evaluating the plausibility of students' claims; EE = Giving or evaluating mathematical explanations; G = Generic comments; LR = Linking representations to underlying ideas and other representations; OL = Considering organization and logistics; PI = Presenting mathematical ideas; RR = Recognizing what is involved in using a particular representation

Note : + Includes follow up question or example from coach
* Denotes attempt to connect multiple MTT Themes

As Table 20 illustrates, even within a smaller excerpt of a given conversation, the coaching moves here led to less instances of generic teacher responses, or responses focused around organization and logistics, as tended to occur in less productive conversations. After the initial coaching moves in Table 20, additional moves were often coded as “follow ups,” indicating the coach’s attempt to use further questions, ideas, or suggestions to press teachers further along related MTT themes. In the following sections, I examine several of these excerpts further.

Posing questions to make connections. Posing a question was the most prominently used coaching move to link problem design and students’ mathematical thinking. In some conversations, this was the only coaching move used to help classroom teachers make such links within the range of coaching conversations from Figure 18. Questions tended to focus on helping teachers anticipate what students already know about the mathematical content, what strategies students might use to solve a particular problem, or to consider the misconceptions or mistakes students might make related to the problem design during planning and how the teacher might adjust the problem design accordingly. In debriefs, questions that connected problem design and student thinking tended to probe teachers about their observations on student understanding of the problem or concept, and at times pressed teachers to consider “next steps” for future problem design based on their observations about student understanding.

Debrief 5 offers an example of an excerpt of a coach using follow up moves to help a teacher make a connection between problem design and student thinking. In turn 13 the coach leads off with an open-ended question that somewhat generally asks the teacher to consider the lesson with regard to the concept of “interval,” and the teacher responds by providing specific evidence of student confusion in turn 14. After the initial response, the coach poses a second question in turn 15, that asks the teacher consider how this evidence of student struggle could inform her problem design for the following day's lesson (Ball, Thames, & Phelps, 2008; Smith & Stein, 2011).

> 13 Coach: …I heard you touch on the interval piece, so let's talk about that a little bit. What are your thoughts about interval? Now that you've taught yesterday.
>
> 14 Teacher: Right, and looking through their notebooks, most of them just copied the definition again, so but when I asked, "What is an interval?" they just verbatim wrote the definition we talked about at the beginning of class. Which is great, it doesn't exactly answer the question, but I don't know where they are. So I had one or two that actually used their own words and it was accurate, but most of them just recopied the definition of what an interval is. And a lot of them still do struggle with that idea, and not having to write, have a number on every single line. And these, they're days and not actually numbers. So that really threw them. So we knew, I knew today we are working on intervals and the construction of a graph, or a line graph, and how to determine that and how to even look at data and say, "Oh, we probably shouldn't, we should concentrate on these numbers as opposed to these numbers."
>
> 15 Coach: Okay. So when you say you're going to look at intervals today what are your specific plans for looking at intervals with the kids? Do you have an idea?
>
> 16 Teacher: Well I have, I made some simple graphs, and so I have just a table of data and we're going to work on that one together and then also on their bell work they're going to take the data, um the data on the table and just put that on a graph. Because even that, they sometimes didn't understand how to make, how to transition from the data in the table to coordinate, um from data table to ordered pairs. So we're working on that.
>
> 17 Coach: Okay, so when you say a simple table, or a simple graph. Are you going to have them specifically look at the data and determine the interval, or…?
>
> 18 Teacher: We're going to talk about the interval together and we're going to discuss where, I'll give them some time to look at it themselves and then we're going to talk about how could we, what should our interval be? Where could we, what should we do with this? And go from there.
>
> (Debrief 5 Transcript)

Here, this secondary question from the coach in turn 15 resulted in the teacher offering an initial insight in turn 16 about her plan, and after a clarifying question from the coach in turn 17, further thinking about the teacher's "next steps" problem design in turn 18.

In this example, it was a series of questions rather than a single question that the coach used to help the teacher connect what she noticed about student struggle around the concept of intervals on a graph and a specific plan to address this during the follow up lesson. This was different from examples in less productive coaching conversations, where more often than the not coach would stop after having the teacher reflect on student understanding and not press them to use this information to plan for future instruction. *Principles to actions: Ensuring mathematical success for all* (NCTM, 2014) explained that it is not only the types of questions that teachers pose, but also the patterns of questions that are important. The authors went on to describe focusing patterns of questioning as those that involved, "…the teacher attending to what the students are thinking, pressing them to communicate their thoughts clearly, and expecting them to reflect on those thoughts…" (p. 37).

This is similar to the patterns of coaching moves I observed in these moderately productive coaching conversations. When coaches used follow up coaching moves, they helped teachers explain their thinking more clearly and reflected on the MTT involved in their decision making before, during, and after the lesson. The use of a range of sequenced coaching moves aligns with work by Huguet, Marsh, and Farrell (2014), who found that strong coaches used a broader range of coaching moves, and with more frequency, than developing coaches. In the instances presented here, using the debrief to focus on students' current mathematical understanding in ways that connected directly to future planning helped to make these conversations relevant and worthwhile for teachers in ways that went beyond the boundaries of a single coaching cycle (Saphier, 2013; West, 2008). The use of follow up coaching moves helped to "focus" the conversations in ways that moved teachers to make such connections.

As Table 20 showed, sometimes the initial question that made the link was around students' background knowledge, which the coach then connected to problem design. In the codes for the Planning 16 excerpt, the coach led off with two questions about students' background knowledge and understanding (coaching moves 1 and 2) to help the teacher clarify her uncertainty of where to go with problem design in a lesson on subtraction with regrouping. After gathering this information, the coach then used a series of coaching moves around problem design to help the teacher connect where she saw a lack of student understanding with her problem design for the lesson (coaching moves 3 through 5 in Table 17), and to anticipate (coaching move 6) what students might do if the problem design were adapted. As this second example of posing questions around this link type suggests, when coaches used multiple coaching moves strung together in thoughtful ways, they focused teacher attention around a wider range of MTT. Asking such questions in tandem also resulted in helping teachers to make connections between MTT themes as well.

Sharing examples or data to make connections. Sharing examples or data to link problem design and student thinking occurred only 9 times across my data. This coaching move was one that the professional literature presented in Chapter 2 (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013) suggested could be productive, but there was little empirical evidence to help coaches understand what it looked like for sharing student work and data to be enacted productively in coaching sessions. This coaching move was typically used in the debrief, when the coach could present evidence from the lesson of student strategies and thinking.

Even in the codes for the excerpt from Planning 24 in Table 20, the coach and teacher discussed the lesson from the previous day to plan for the coached lesson around the topic of problem solving. In this brief exchange, the initial coaching move was to pose a question about problem design, here related to how the teacher might get students talking and sharing mathematical ideas. To further illustrate the relevance of this, the coach shared an example of a student's mathematical thinking from the previous lesson, explaining that the student had an important mathematical idea but remained silent in the moment. The coach's third move was to ask a follow up question for the teacher to consider how to help students in these instances contribute their thinking during class discussions in order to move conversation forward productively. These probing sorts of questions (Boaler & Brodie, 2004) provided the teacher opportunities to better articulate and clarify her thinking in ways that were focused around these two MTT themes. From here, the conversation continued around ways to modify the lesson set up, both by adjusting the tools that students were given to use, as well as by pre-planning "productive mathematical questions" (Ball, Thames, & Phelps, Content knowledge for teaching, 2008) to get students explaining their thinking more clearly in front of the group during the next lesson. By offering the teacher a specific example of sound student mathematical thinking that was overlooked during the previous lesson, the coach pressed the teacher to address future problem design in ways that might prevent this issue from happening again.

Examples such as this stand in contrast to coaching moves in less productive and linear coaching conversations, where talk around student thinking typically ended after reflecting on what students did and did not understand. When coaches shared examples of student thinking *and* pressed teachers to consider this information as it connected to problem design, these moves played out more productively by helping teacher consider actionable "next steps" based on their analysis of student thinking. Using multiple coaching moves to help "focus" the teacher's attention on MTT and connecting MTT themes helped to foster this productivity. This is an idea I will come back to in the final part of this chapter when I examine the strongest examples of productive coaching conversations in my data.

Offering suggestions and ideas to make connections. Although not nearly as prominent a coaching move as asking questions, sharing suggestions and ideas was a third way that coaches made links between problem design and student thinking. Table 20 illustrates how the coach in the codes for the Planning 1 excerpt used a series of coaching moves to connect problem design and student thinking. The coach's initial move was to gather background information by posing a question about student struggle (coaching move 1) in order to help the teacher think through this struggle as it related to problem design. After the coach allowed the teacher time to explain what it was about problem contexts she believed caused the struggle, and what representations and strategies she has tried in the past ("recognizing what is involved in a particular representation" (Ball, Thames, & Phelps, 2008)), the coach then restated the implied mathematical goal to develop a focus for the teacher's intended plan. This included the fact that the teacher uses an online resource to find the word problems she uses in her lessons. The coach's third move was to suggest using a literacy strategy called "Bet Lines" (Dick, et al., 2016)[1] to help students think more deeply about problem contexts when solving word problems with fractional operations.

---

[1] Bet Lines are a literacy based strategy where students are shown the first line of a word problem and asked to make predictions, or "bets," about what will happen next. The teacher can pose questions asking students to anticipate the contexts and mathematical operations that would connect to their guesses, before revealing the next line of the problem. Before revealing the last line, the teacher might pose a

The coach led the conversation for several turns, explaining what a “Bet Line” was and how it would look to use the strategy to help students consider the context of word problems. Once the teacher appeared to be open to the suggestion, the coach then shifted from explaining the suggested strategy to asking the teacher about how it could be incorporated into the coached lesson in coaching move and response 4 (Table 20). In this instance, the teacher took the coach’s suggestion about problem design and the discussion continued at some length as to what it might look like to use the types of problems the teacher already had planned for the lesson, but present them in such a way that students made predictions about how the problem would end before being presented with the entire problem to solve (“presenting mathematical ideas” (Ball, Thames, & Phelps, 2008)). The excerpt provides evidence of multiple attempts on the part of the coach to help the teacher consider how her concerns about student struggle influenced the lesson design. The coach additionally made a brief reference to the teacher’s intended mathematical goal as a result of this talk around student struggle, and used this information to offer a suggestion about adapting problem design to address this concern.

One important thing to note is that the coded excerpt from Planning 1 led to an enacted suggestion, whereas some other suggestions were unincorporated during lesson enactment. Planning 22 offers an example of this. Although the coach used a series of coaching moves to offer a suggestion, and posed follow up questions for the teacher to consider how students might respond to a problem adaptation in Table 20, much in the way the coach did in the excerpt from Planning 1, in my field notes for this coaching

---

question asking students to predict what the question will be and what mathematics would be done to solve.

cycle, I noted that the teacher did not use the suggestion during the lesson. Unincorporated coach suggestions occurred a total of 3 times throughout my data, based on a comparison of the planning conversations and my field notes from lesson observations. Coaching Cycle 22 included the most extended discussion on a suggestion during the planning that was left out during instruction. This leaves a lingering question as to whether productive coaching moves are considered as such when they only got the teacher talking through aspects of MTT during the planning conversation, versus when the teacher used these mathematical ideas during their lesson. When the coach's ideas were taken or not during coaching conversations, did this determine their productivity? Although there may not have been adequate examples of this across my data to know for certain, in this instance, it is possible to examine the contextual factors involved further to understand the difference between how these two scenarios played out.

Specific Coaching Moves to Connect Mathematical Goals and Problem Design

A second type of link that coaches made in more productive coaching conversations was between mathematical goals and problem design. According to Table 12 (Chapter 4), coaches attempted to help teachers make this type of link in only 13 of the 34 conversations in the data I categorized as more productive. Figure 20 illustrates this link and the different coaching moves used to help teachers make this type of connection.

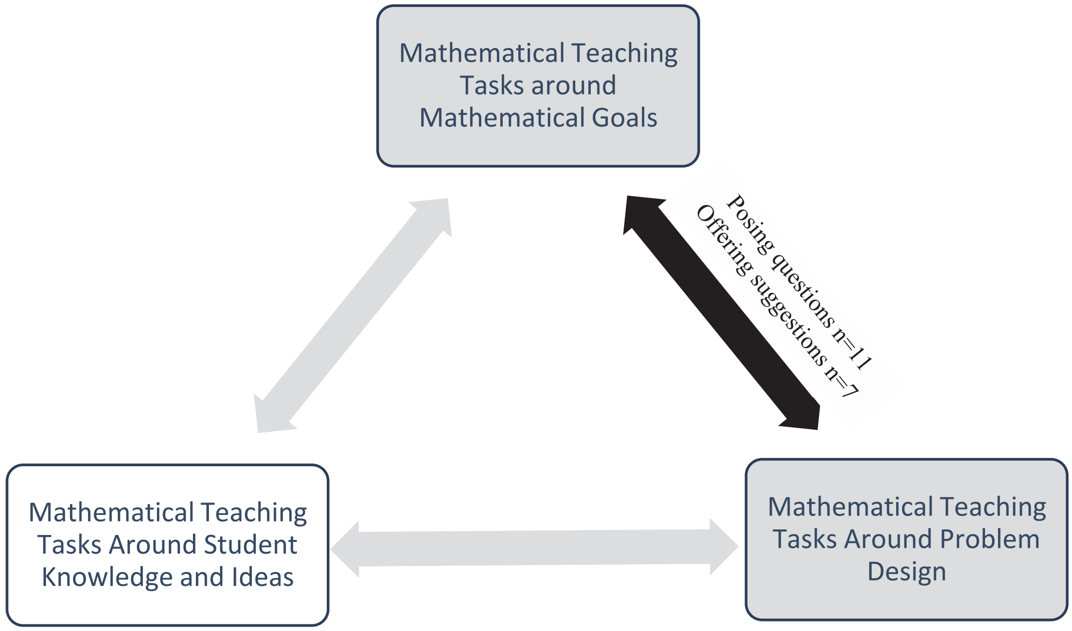

Figure 20. Types and counts of coaching moves connecting goals and problem design.

Like the first link type, coaches most often posed questions to help teachers consider ways in which goals influenced problem design and vice-versa, as Figure 20 shows. In these more productive coaching conversations, there were 11 instances where coaches posed questions to make connections among these two MTT themes. Offering suggestions and ideas, although the second most frequently utilized coaching move to make this link, only occurred a total of 7 times in my data. Sharing examples and coaching moves I categorized as "other" were infrequent across coaching conversations (only 1 occurrence of the former in my data and 3 of the latter), therefore in this section I focus on posing questions and offering ideas or suggestions to illustrate the work of coaches that made this link.

As the coded examples in this section illustrate, coaching conversations did not tend to linger on the topic of mathematical goals for long. Unlike coaching moves that might begin an extended dialogue about problem design and student understanding, coaching moves around mathematical goals and problem design tended to result in briefer discussion, as Table 21 shows.

Table 21

Examples of Coaching Conversation Codes of Excerpts Where Links Between Goals and Problem Design Occur

Coaching Session	Coach Moves & Teacher Responses	M 1	M 2	M 3
Planning 21 (Posing Questions)	*Coach Move* [a]	*QMG**	*QMG+*	*QPD+*
	Teacher Response [b]	EC	EC	LR
Debrief 23 (Posing Questions)	*Coaching Move*	*QPD, QMG**		
	Teacher Response	PI, LR		
Planning 13 (Offering Suggestions)	*Coaching Move*	*SPD**	*SES+*	
	Teacher Response	SR	LR	

[a] Coach Move: QMG= Question about mathematical goals; QPD= Question about problem design; SES= Sharing examples of student thinking; SPD= Suggestion about problem design

[b] Teacher Response: EC= Evaluating plausibility of students' claims; LR= Linking representations; PI= Presenting mathematical ideas; SR= Selecting representations for particular purpose

Note : + Includes follow up question or example from coach
* Denotes attempt to connect multiple MTT Themes

Often after only a few turns in the dialogue, the coded conversation would shift from questions and statements clarifying the goal to talking about problem design again. This was a feature of coaching moves making this type of link that differed from those that connected student understanding, although this may be reasonable as there is a wide array of things to discuss when considering student abilities and backgrounds in lesson design. Table 21 shows three codes of excerpts from coaching conversations that illustrate coaching moves used to connect mathematical goals and problem design, two initiated by the coach posing a question, and one by offering a suggestion. I examine these three examples further in the following sections.

Posing questions to make connections. Much like making links between problem design and student thinking, asking questions was the most often utilized coaching move across my data to help teachers make connections between mathematical goals and problem design. In Table 21, I offer two coded examples of coaches posing questions to make this link. In Planning 21, for example, the coach asked two questions (coaching move 1 and a follow up move 2) to ensure she understood what the mathematical goal was before posing a third question about problem design to help the teacher ensure the goal aligned to the problem set up and enactment during the lesson. Doing so helped the teacher to ensure the activities she planned to use for the lesson were aligned to her intended learning goals for students throughout, rather than developing activities that were engaging but perhaps missed the intended point of the lesson (Moss & Brookhart, 2012).

This example was typical of the ways in which coaches used questions to help teachers make connections between their mathematical goals and the problem design of the lesson during planning conversations. The questions of the coach sought to clarify either the goals or the problem design in ways that helped the classroom teacher to consider the alignment of the two as they were discussing problem set up (e.g. "How will that problem help students understand your intended goal of…?"). Typically, coaches did not ask questions during the debrief that linked problem design and goals, they most often used questions in the debrief to investigate the extent to which the mathematical goals were met based on evidence of student understanding (e.g. "How well do you think students understood the problem?"), rather than reflecting on how the problem design itself did or did not help meet the intended goal. The one exception to this in my data occurred during Debrief 23, where the coach and teacher discussed students' current understanding of equivalent fractions and adding fractions with unlike denominators, including some lingering frustration by the students when the lesson stopped so they could attend P.E. In turn 3 in the following excerpt, the coach followed up the teacher's comments about the multiple connections that needed to be made still between visual representations and procedural methods for finding equivalence with a question about next steps ("linking representations to underlying ideas and other representations" (Ball, Thames, & Phelps, 2008)), which connected back to the teacher's intended mathematical goal in turn 5.

3 Coach: So are you devoting any more time today to that?

4 Teacher: Mmhm. Oh go ahead…

5 Coach: Because I was just kind of thinking of like for some of them out there because I hate to do this to kids, I hate to leave them feel frustrated or dumb or something like that, you know that's the worst thing you want in math classes. So I was like so what is the focused objective, the essence that we want kids to walk away with and say, "I can do this today, I understand this." What do you want?

6 Teacher: Well I was going to pull out the Go Math on this which is basically just adding them and it says to simplify them, but I won't make them simplify. So I think really what I want them to do is to be able to put the two pieces together to find equivalence and solve it, so really just that finding the equivalence piece of it to have the common denominator. So I think that's kind of where were going to pull back to as our ultimate like, "If you're getting this you're in pretty good shape as of right now," you know, kind of because I know that they're feeling a little bit overwhelmed. I mean some of them not very much, but some of them to just, throwing a lot their way.

7 Coach: Yeah, I was kind of thinking on the same lines as you. When we, if we go back to almost like so, you talked about a lot of things but the purest, what we really want to understand today, this is our whole objective is that you cannot just add the numerators and add the denominators. If you understand that, you're fifty percent there. Who understands that? Raise their hands. It, that was beautiful. So say, "What do we need to do?" We need to find something in the denominator that is equivalent.

8 Teacher: I think when we get to this piece which, actually my son has pink eye so I won't be here tomorrow, but probably Monday again, because tomorrow will be math with sub is not math that I'm okay with usually. When I get back to this piece I want to pull back out those pieces again. Pull back out those fraction bars and show them how we change that denominator and will still have equivalence [Walks away to answer the phone]. Sorry. So, I guess I feel like when we get to the part when we're changing it to just that finding the common denominator and adding,

> when we get there which, we're not there yet, I want to pull back out those pieces and make that proof that what we're doing is tied in to and representing what we did in the past.
>
> 9 Coach: But for today it's like, if they can use the blocks to add two fractions with unlike denominators, they've mastered the basics. I think if you clearly communicate, hey we did a lot of extra stuff today, but this is the stuff that matters the most. Do you think they'll be comfortable? Because they can all do that.
>
> 10 Teacher: Yeah, I think what will happen is if I say that when we start our assignment I think that I'll have some kids like E__ or some of the kids who can do it who will say, "I don't get it." And then as soon as they sit with me and I'm like, "Okay, do this." And they do it, they'll be like, "Oh yeah, I can do this." I think that it might take a little bit of confidence building with a few of those kids who felt a little lost as we progressed, but I think they can all do it.
>
> (Debrief 23 Transcript)

The coach referred back to the goal in turn 5, which pressed the teacher to explain how she planned to wrap up the lesson after students returned from P.E. in order to bring closure to the day's work. From there, the teacher went on to talk further with the coach about her "next steps" for moving toward a broader goal of helping students develop efficient procedures for adding fractions with unlike denominators that were based on conceptual understanding in turn 8, and the coach's final move in turn 9 once again addresses students' current mathematical understanding of the day's objective.

Besides being one of the only occurrences of a coach asking a question during a debrief conversation to link MTT around mathematical goals to those around problem design, it is worth noting that the question came up in part because the debrief took place while students were at P.E., and the coach was unable to come back to observe the end of the lesson afterward. The fact that the coach recognized student struggle during the lesson as evidence worth sharing allowed the teacher an opportunity to address how well the problem design was meeting her intended goal before the lesson finished. This demonstrates the sort of responsive coaching (Ippolito, 2010) that can afford opportunities for coaches to help teachers make these sorts of connections between intended mathematical goals and problem enactment.

Offering suggestions and ideas to make connections. In other instances, coaching moves that helped teachers connect problem design and mathematical goals were less direct, and played out in the form of the coach offering a suggestion, such as adding a mathematical element in to the problem design, in a way that refined the lesson goals. Much like the move of asking questions to make this link, offering suggestions and ideas to connect problem design and mathematical goals tended to happen during planning conversations rather than debriefs throughout my data. The codes for the excerpt from Planning 19 in Table 21 focused around the teacher's mathematical goal of helping students recognize what was "ten more" or "ten less" than a given two-digit number. As the conversation shifted toward discussing the closing activity and the teacher appeared not to have a plan for summarizing student learning, the coach offered a suggestion (coaching move 1) on how to adapt the problem design to connect back to this goal. The coach offered a follow up example of what students might say and do to illustrate the connection to the teacher. The teacher appeared to be receptive to this idea, explaining that this activity connected to what students had to do in the written assignment using mental math rather than a hundreds chart to find ten more and ten less.

In talking to the coach after the coaching cycle about why she felt this was important to include, she explained to me,

> I wanted them when they were doing the hundreds chart, I wanted them to see, because it seemed like they knew but I didn't know if they just knew drop down or drop up, they seemed to just know that, but I didn't know if they understood why…and I didn't know if she had talked about that, or if she had thought about that before. (Interview with coach, Cycle 13).

In this instance, the coach had a specific mathematical connection she wanted the teacher to be sure students were making, in understanding the idea of ten more and ten less more than just “drop down or drop up” on the hundreds chart, and seeing the adding and removal of a ten each time.

By offering a suggestion to adapt the problem design at the end of the lesson, the coach hoped to help the teacher assess for a deeper level of student understanding around this mathematical goal of ten more and ten less than the original problem design pressed for. This suggestion helped the teacher to increase the cognitive demand for students, a reform-oriented practice promoted in the current literature (Stein, Smith, Henningsen, & Silver, 2009). Although these conversations attempted to make links that the less productive and linear conversations did not, teacher responses to these moves still tended to be brief and less detailed in nature in the excerpts from this section than in the previous examples of coaching moves that connected problem design and student thinking. Such examples illustrate one instance of the limited amount of time teachers and coaches spent focusing around mathematical goals across my data, even in more productive coaching conversations.

Specific Coaching Moves to Connect Mathematical Goals and Student Thinking

Like instances where coaching moves attempted to help teachers make a link between mathematical goals and problem design, moves that attempted to link goals and students’ mathematical thinking were much less pervasive throughout my data than ones that connected problem design and student thinking. Only 13 total planning and debrief conversations in the more productive coaching conversations across my data contained instances where the coach attempted to connect these two MTT themes, and often they occurred during the debrief when there was evidence of student understanding to connect back to. Figure 21 illustrates the types of coaching moves used in these conversations.

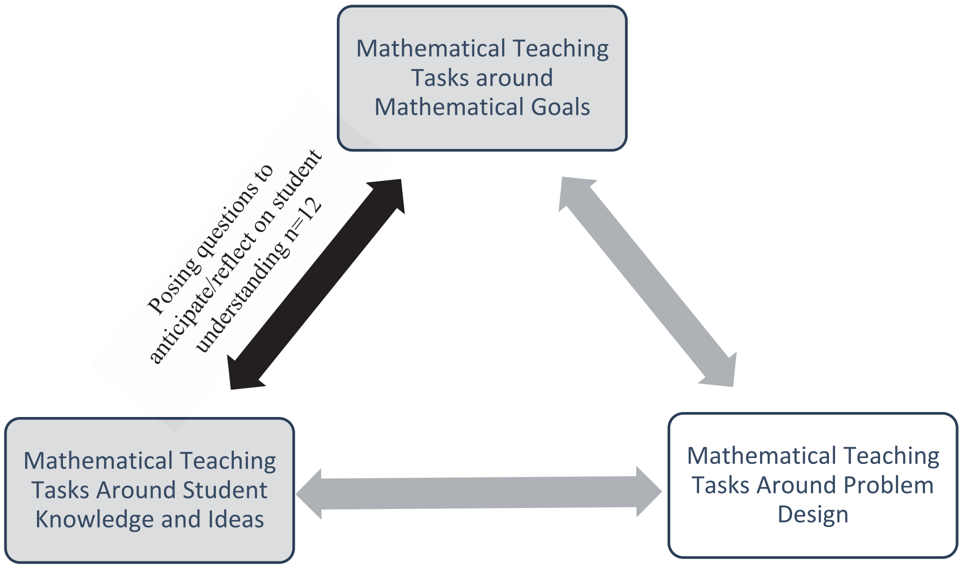

Figure 21. Types and counts of coaching moves connecting goals and student thinking.

As indicated in Figure 21, most often, making this connection occurred by either posing a question about the mathematical goal that led to considerations about student background knowledge or how to gauge student understanding of the goal by the end of the lesson. Occasionally, coaches would use other coaching moves as well (1 instance of offering a suggestion, 2 instances of sharing examples, 2 categorized as “other”), but by far asking questions was the most frequently relied upon coaching move to make this type of link, therefore it is the only coaching move I will focus on in this section, as indicated by Table 22.

Table 22

Examples of Coaching Conversation Coded Excerpts Where Links Between Goals and Student Thinking Occur

Coaching Sessions	Coach Moves & Teacher Responses	M 1	M 2	M 3
Planning 1 (Posing Questions)	*Coaching Move* [a]	*RMG*	*QAS+**	*RMG+*
	Teacher Response [b]	RR	EE	SR
Debrief 26 (Posing Questions)	*Coaching Move*	*Q*	*QAS+*	*QAS+**
	Teacher Response	EC	EC	LR

[a] Coach Move: RMG= Restating mathematical goals; Q= Generic question; QAS= Questions to anticipate student thinking

[b] Teacher Response: EC= Evaluating the plausibility of students' claims; EE= Evaluating/giving mathematical explanations; LR= Linking representations; RR= Recognizing what is involved in a particular representation; SR= Selecting representations for a particular purpose

Note : + Includes follow up question or example from coach
* Denotes attempt to connect multiple MTT Themes

Table 22 offers codes of excerpts from two coaching conversations where coaching moves made connections between mathematical goals and students' mathematical thinking. Often, the coach only made inferential or brief connections between the two MTT themes, which can be seen through the brief number of coaching moves used to make these connections in the codes of conversation excerpts in Table 22. In the following section, I examine these examples further.

Posing questions to make connections. Many of the examples of coaching moves in this category were worded in ways that made only weak or superficial links between student thinking and mathematical goals. For instance, during the conversation in Debrief 27, after the coach and teacher finished discussing observed student confusion between area and perimeter that occurred during the lesson, the coach asked a follow up question to help the teacher to consider the how well the mathematical goals of the lesson were met, stating, “By the end of class today, do you think they knew that we were really talking about perimeter confidently?” Despite having just finished an extended discussion of the observed evidence of student thinking just before this question was asked, the teacher responded here, “I’d say some of them, yeah,” (Debrief 27 Transcript), but she did not offer any evidence about student thinking to support this remark, and the conversation shifted back toward problem design without any further pressing on the part of the coach to elaborate. Like some of the examples presented in the section on less productive coaching conversation, this excerpt presents a potential missed opportunity for the coach to use additional follow up moves to press the teacher to consider this question in more detail.

In Planning 1, the teacher explained to the coach that her objective for the lesson was to have students solve word problems involving the multiplication and division of fractions, however she expressed a point of anticipated student struggle during the lesson. The coach attempted to clarify this confusion by posing a series of question about the source of the confusion, prior to the coded excerpt shared in Table 22. After the teacher spent some time talking through an observed challenge for students to understand operations within the context of word problems, the coach was the one to state the link between what students were struggling with mathematically. In coaching move 1 in Table 22, the coach explained how this struggle related to the teacher’s intended goal for the lesson of helping students to understand the types and contexts of various multiplication and division situations in word problems. The coach followed up with another question about where the teacher saw a “break down” in student understanding (coaching move 2), and she used the teacher's response around evaluating her students' explanations to restate and further refine the goal as it connected to these issues in coaching move 3.

In this instance, much like other examples of productive coaching moves throughout this chapter, it was not a single move but the coach's series of questions that led the teacher to define more exactly what she means when she says students are struggling. Although the coach did not pose a direct question about mathematical goals here, the implication was that the teacher wanted to focus on helping students understand contextualized situations with fractions as a mathematical goal, which the coach restated directly in both coaching move 1 and 3 in Table 22. From here the coach guided the conversation toward the overall design of the lesson to help the teacher develop a plan that was intended to help students focus on visualizing the problem and learn to recognize multiplicative contexts in word problems, using a focusing pattern of moves (Herbel-Eisenmann & Breyfogle, 2005). Posing questions here helped the teacher to reflect on and more clearly articulate issues with student understanding in ways that help to inform the mathematical goals of the lesson that stands in contrast to the previous example from Debrief 27. From there, conversation shifted to problem design as a result and moved away from a discussion of goals. When coaching moves related to mathematical goals and student understanding played out in these sorts of ways, they tended to be more productive as a result in that they began to help teachers make links between not only two, but often among all three MTT themes within the same conversation.

Another vignette that included coaching moves that connected mathematical goals and student thinking occurred during Debrief 26. Several features of this example differ from other coaching moves in conversations that were categorized as "more productive."

For instance, here the initial coaching move was coded as a generic question, asking how the teacher thought the lesson went in turn 1. In examples of less productive coaching conversations, this type of non-specific coaching move often led to non-specific responses or responses unconnected to MTT on the part of the classroom teacher. A unique feature in this example then, was that the teacher required little prompting here to talk through her observations of student struggle in turns 2, 4, 6, and 8 before shifting toward focusing on her mathematical goal of pushing students to persevere through challenging and inquiry-based mathematical problems near the end of turn 8. This focus on implementing a problem that promoted problem solving and supporting perseverance and productive struggle aligned with the reform based mathematical teaching practices discussed in the current professional literature in Chapters 1 and 2 (NCTM, 2014; Stein, Smith, Henningsen, & Silver, 2009).

1 Coach: Alright so what do you think? How did it…?

2 Teacher: I don't think they understood the problem at all.

3 Coach: No. At all ever? Or? The whole time or?

4 Teacher: I mean, I think towards the end it started to somewhat, but I still even think then they didn't really have a full grasp on what, do you think they did?

5 Coach: Full grasp? No.

6 Teacher: Like when it was just them trying to work the problems they had no idea. Like whenever you finally got up there and concluded it all and it was like oh. But then I think it was you saying, "Okay, it's okay for us to have two different ways. It's okay for it to look like this." So then you were telling them, I don't know, almost reassure...I don't know.

7 Coach: Talk to me about that. Keep going.

8 Teacher: I feel like they can't, they almost second guess their thinking, like when they're coming up with stuff like that so whenever you finally got up there and was like reassured them that it's okay for it to look this way and for it to look this way, then it was almost like they were like, "Oh!" I don't know. I feel like they have a hard time of the whole "explore" before you tell them, "Blah, blah, blah, blah, blah, blah, blah," and I mean like, "This is how it is. This is what we're supposed to do." And if you just kind of throw it out there for them they're just kind of like looking at you like, "What are we supposed to do?" And a lot of that's because we were just starting this whole "explore" thing, you know, and I get that but then the same time I'm like, is it

> part of the age too? I mean, if I would've started this early on, would they, of course they would, but I don't know, I'm sorry, I'm just still…
>
> 9 Coach: No. What was that question that you cut off for yourself? This, "Of course they would"?
>
> (Debrief 27 Transcript)

In turns 3 and 5 the coach asked follow up questions that sought to clarify what the teacher noticed about observed student understanding, and as the teacher shifted the focus of the conversation herself in turn 8, the coaching move in turn 9 again focused the teacher to continue talking rather than asking a question specific to student thinking or mathematical goals.

> 10 Teacher: Would they be able to, be able to think and question and do all of those things that I'm trying to get them to do? To question and to think about the problem without me, to explore the problem on their own and be able to talk their way through how they found the answers, all of those things that I want to get them to. Instead of just looking at me, waiting for me to walk through the steps with them because that's what they're used to.
>
> 11 Coach: Yeah. So, do they in the process of going from where they're, let's say they're going from a process from where they were at to where they're at, to where they're going… Do they need my reassurance that, "Yeah that's okay?"
>
> 12 Teacher: Yeah I think so…I think that they should be reassured after the fact, you know? Or, and you do that through pulling out the different ways of working through the problem. But I don't think that the reassurance should be given before they even start to explore the problem.
>
> (Debrief 26 Transcript)

The coach listened to the teacher continue reflecting on whether more time and opportunities for students to work through solving problems this way might have helped them move away from the expectation that they must wait for the teacher to *tell* them what to do in turn 10. In turn 11, the coach then followed up with a question to press the teacher about offering reassurance to students in response to her remarks about students waiting for support. The result of the coaching move in turn 11 was the teacher expressing an implied goal in turn 12 of wanting students to be able to persevere and find strategies to solve problems, one of the CCSS-M mathematical practices (National

Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), *before* she stepped in to reassure during the lesson.

From here the conversation shifted toward this idea of students not being there *yet*, and the coach reassured the teacher that such a large mathematical goal will take time. The coach asked one more question connecting this goal toward the teacher's observations of student understanding, "Do you think that we took steps from last time?" (Debrief 26 Transcript), which moved the conversation toward talking about aspects of the problem design that led to students making progress from the previous lesson. Using more generic versions of coaching moves such as asking questions and pressing teachers to explain their reasoning rarely resulted in this extensive sort of reflection and dialogue around specific aspects of MTT in any other places in my data. To better understand why this may have occurred in this instance, it is necessary to examine the contextual factors at work in this coaching cycle. In the final section analyzing "more productive" coaching, I discuss the contextual factors present across these conversations.

Contextual Factors in Moderately Productive Coaching Conversations

As with the examples of less productive and linear coaching conversations, there was evidence of a range of contextual factors present across coaching conversations I coded as moderately productive across my data. One distinct difference between my examination of contextual factors in these instances and those in the previous sections is that, although in some moderately productive conversations these factors may have potentially contributed to less productive coaching moves, in other instances, conversations were still productive despite the presence of potentially negative factors.

Figure 22 illustrates the contextual factors I coded across the 34 moderately productive coaching conversations.

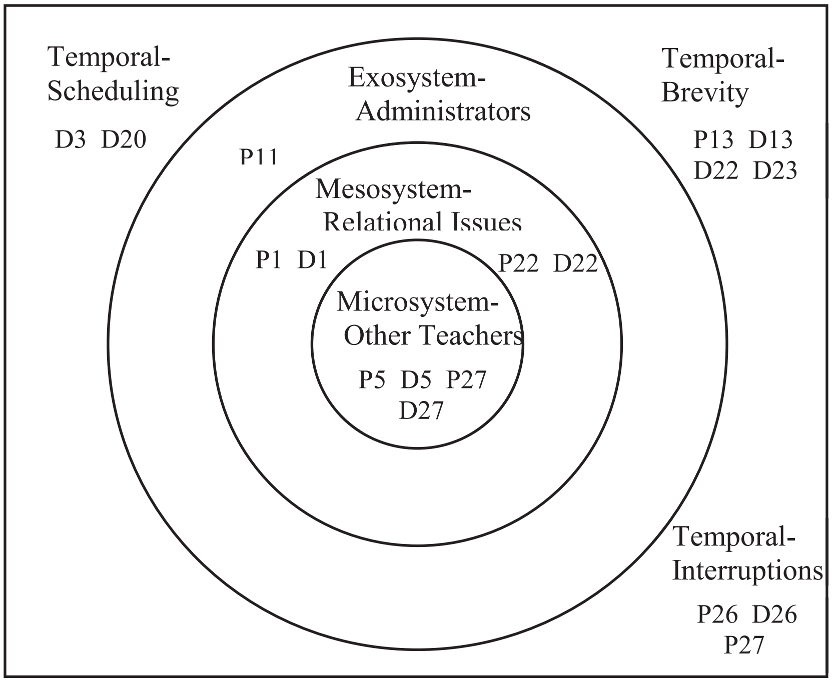

Figure 22. Contextual factors in moderately productive coaching conversations
Note: P1= Planning 1; P5- Planning 5; P11= Planning 11; P13= Planning 13; P22= Planning 22; P26= Planning 26; P27= Planning 27; D1= Debrief 1; D3= Debrief 3; D5= Debrief 5; D13= Debrief 13; D22= Debrief 22; D23= Debrief 23; D26= Debrief 26; D27= Debrief 27

As with the less productive and linear coaching conversations, moderately productive conversations showed evidence of microsystemic factors, mesosystemic factors, one instance of an exosystemic factor, and several temporal factors across my data. It was perhaps not surprising that oftentimes these factors influenced both the planning and debriefing sessions for a coaching cycle, as it was the same coach and teacher participating in both. The instance of the exosystemic factor was a bit uncommon, in that the building principal observed and participated in Planning 11, which may have potentially influenced the direction of the conversation. In the instances of Debrief 3 and Debrief 20, the coach was unable to schedule a face to face debrief, and so the conversations took place via email. Beyond these two exceptions, many of the remaining factors were the same as in my earlier discussions. I will address similarities and differences between how these factors played out in more and less productive cycles further here.

Microsystemic factors- other teachers. Similar to previous sections in this chapter, factors that stood to directly interact with the teachers' beliefs and relationship with the coach were present in several moderately productive coaching conversations. As Figure 22 shows, both Planning 5 and 27 and Debrief 5 and 27 were conversations where there was evidence of microsystemic factors present. In cycle 27, the coach shared with me that the rest of the teacher's grade level team did not collaborate with her, making it a challenge to schedule with the teacher at times (Interview with coach, Cycle 27). In cycle 5, on the other hand, it was the teacher who expressed to me that sometimes her work with the coach may have made her feel at odds with the rest of her grade level team. She shared with me,

> Sometimes, we do a lot of rotations, we starting to do rotations and that's not always as common in other classrooms, and so my classroom looks a bit different than other classrooms on my team and then, you know just different classrooms, and kind of communicating, "Well this is what the coach is kind of helping me work with," versus, "Well that's not how I do it." There's sometimes kind of a disconnect between that.
>
> (Interview with Teacher, Cycle 5)

Despite the presence of these potentially negative factors, both coaches assured me that the two teachers were open to working with them. Figure 18 shows that three of these conversations fell in the upper third of the figure, indicating that the coach made one link among MTT themes in Planning and Debrief 5, as well as in Planning 27. In Debrief 27, the coach made two links between MTT themes. Planning 5 and 27 showed higher counts of MTT discussed (5 MTT in Planning 5 and 6 MTT in Planning 27), indicating that the coaching moves helped the teachers attend to a broader range of teaching tasks in these cycles. Although microsystemic factors may have been evident, in these instances the coaches maintained productive conversations with the teachers in spite of their presence.

Mesosystemic factors- new coach-teacher relationships and perceived relational issues. Two of the coaching cycles in this categorization of my data presented evidence of possible mesosystemic factors, where the actual relationship between the teacher and coach potentially could have impacted the coaching cycle. In the instance of Planning and Debrief 22, the coach explained that the relationship with the classroom teacher was one that was developing, stating in turns 10 and 12 what the coach may have perceived as a potential challenge in helping the teacher to reflect on certain aspects of her planning and teaching.

> 10 Coach: It's a good relationship, but A__ still is, A__ is developing some reflectiveness in her teaching. So, like I'm slower.
>
> 11 Interviewer: So, when you say developing reflectiveness, how do you see that being different, I don't know, from maybe a teacher who doesn't work, whose (…)?
>
> 12 Coach: I would just say it's like whereas, some teachers you can just go right in and start talking about teaching practices and looking at how they're doing things, and whether it's working or not. Like A__'s not quite as set, or she's more set and less able to adjust. Does that make sense?
>
> 13 Interviewer: I think so, yeah. I'm just trying to clarify as much as possible so when I go back I can remember.
>
> 14 Coach: I walk more gently in and so my suggestions are…
>
> 15 Interviewer: So more set in that she doesn't like to deviate from a lesson plan or a teaching plan or?
>
> 16 Coach: She has her ways that she thinks it's going to work and is less adjustable to other ways of thinking.
>
> (Interview with coach, Cycle 22)

Turns 12 and 16 may suggest that, at least from the perception of the coach, it was possible that this teacher may not have been as open to taking on risks or suggestions that deviated from her anticipated plan for the lesson and the mathematics at this point in the coaching relationship, however it is beyond the scope of my data to know for certain. When considering whether the presence of perceived relational issues may have influenced the teacher's decision not to incorporate the coach's suggestion during her lesson, although I have no definite evidence to support or disprove this, the existence of a potentially negative contextual factor during this cycle is important to note.

In Planning and Debrief 1, the coach expressed to me her uncertainty as to how receptive the teacher was to working with her. This teacher was not one who participated in the three part coaching cycle very frequently with the coach, and was someone the coach perceived to be less open to working together. After the debrief, the coach shared, "I can envision her talking to other teachers negatively about it, even though she seemed pretty okay with it" (Interview with coach, Cycle 1). Despite this, Planning and Debrief 1 both appeared near the bottom of Figure 18, as the coaching moves helped the teacher to attend to 8 MTT in the planning and 5 MTT in the debrief, and in both conversations was able to help the teacher to connect two MTT themes. Despite the presence of potentially negative mesosystemic factors in this cycle, the coach's use of follow up coaching moves to press the teacher to talk at length about a range of MTT led to more productive coaching than in Planning 22. It is possible then, if coaches use the right combination of coaching moves persistently, to help conversations be productive in spite of some of these perceived relational barriers.

On the opposite end, coaches in many of the other coaching cycles throughout this section categorized their relationships with the coached teachers as positive. In the instance of cycle 26, for example, the coach had shared with me that work with this particular classroom teacher was ongoing and frequent. In the post-observation interview, she expressed excitement to me about the progress she felt the coaching process was having on this teacher's practice, stating,

> I'm really excited about how this is going, because I think even from when I was in there yesterday to today, she seemed, I think if coaching wasn't connected, this is an instance where a teacher might try something and then it didn't go great and then just abandon it after day one. And kind of, I'm excited about this because with this little extra support and feedback and encouragement, it's like a teacher is potentially going to latch on to a worthwhile practice that could last (Interview with Coach, Cycle 26).

The presence of a positive and seemingly well-functioning mesosystem between the coach and teacher in this coaching cycle, at least from the perspective of the coach, resulted in the teacher beginning to develop a deeper understanding of the features of her teaching practice around MTT that were important to consider during planning and debriefing sessions with the coach. When teachers begin to anticipate the sorts of coaching moves and topics that are typical for coaches to bring up in this work, it is possible that the wording of the coaching moves matters less, as occurred in this example in my data.

Temporal factors- scheduling, brevity of conversations, and interruptions. Beyond coaching cycles where the debrief was unable to take place face-to-face, some of the moderately productive coaching cycles were either briefer (less than 15 minutes in length) or had interruptions that occurred during the coaching conversation. Planning and Debrief 26 were interrupted by phone calls to the classroom teacher; in both instances, the teacher and coach attempted to refocus the conversation on the MTT discussed prior to the interruption. In the instance of Planning 27, the coach was the one to cause the interruption, leaving the room to retrieve her calendar because the coach and teacher determined they wanted to make a change in which lesson the coach observed. In all three situations, the coach and teacher moved past the interruption to continue lengthy (over 20 minutes) conversations around MTT, therefore this temporal factor did not seem to influence the conversations overall productivity, much like what happened in less productive coaching sessions.

As often happens, a lack of time for extended coaching conversations was still an issue at times in more productive coaching conversations. Although most of the coaching conversations in this more productive range tended to be between twenty and thirty-five minutes in length, there were still 4 conversations that were less than 15 minutes in length. Despite the brevity of Planning and Debrief 13 (10:21 and 7:01 in length, respectively), the coaching moves in these conversations placed them in the middle of Figure 18. The coaching moves led to teacher conversation about 3 or more MTT and in both conversations helped the teacher make two connections among MTT themes. Similarly, Debrief 22 appears in the middle of Figure 18, as the coaching moves in this conversation led to talk around 4 MTT and helped the teacher connect two MTT themes. Debrief 23 was the longest of these four examples, at just under 15 minutes in length, yet was categorized as the least productive of the group according to Figure 18 because the coaching moves only made one connection between MTT themes.

It is possible that a lack of adequate time could make it difficult for the coach to use enough to get teachers discussing a wide range of MTT. Debrief 13 is an example of this, with only 7 minutes for the coach and teacher to talk, and coaching moves only led to discussion of three distinct MTT. Planning 16, on the other hand, was 36:50 in length, and the coach used coaching moves to provoke conversation around 7 distinct MTT and make two different types of links among MTT themes, moving it farther down the list of productive interactions in Figure 18 than Debrief 13. At the same time, Debrief 5 was 20:25 in length, and despite the fact that the coach and teacher had extended discussion about what students struggled to understand around the idea of graph intervals, the overall conversation still centered around only three distinct MTT. Even though the coach in Debriefs 5 and 13 used coaching moves that only got the classroom teacher talking about three different MTT in different timeframes, the coaching moves in Debrief 13 did so in ways that helped the teacher make more links among the three MTT themes in a much briefer conversation. These examples illustrate that the amount of time allowed for a coaching conversation is not necessarily a good predictor of overall productivity of coaching moves.

These instances provide evidence that, like less productive coaching sessions, more productive coaching sessions were faced with contextual factors that could potentially influence how coaching moves played out in different conversations. In certain examples, coaches worked within the presence of these contextual factors in ways that were more productive than others, indicating that it is possible to overcome the perceived barriers these factors create at times. In other instances, certain contextual factors such as the mesosystemic relationship between the coach and teacher may have been positive in nature. When coaches used coaching moves that include follow up questions to help teachers speak more at length about various MTT, and made links among the themes of problem design and student thinking, the coaching conversations were more productive than in the earlier sections where coaches tended not to follow up at all. Similarly, when coaches shared ideas and helped teachers visualize how to incorporate these ideas into their problem design, such moves helped teachers consider aspects of MTT that went beyond surface level conversations. In the final section of this chapter, I address conversations I coded as the most highly productive instances of coaching moves, and continue my examination of the interplay between contextual factors and productive coaching.

Highly Productive Coaching Moves

In this final section of Chapter 5, I present examples of the sorts of coaching moves I categorized as "highly productive" based on my analysis and definitions developed in Chapter 4. This helps to complete the picture my data can present to help address questions left by the existing literature in Chapter 2 as to the types and enactment of coaching moves that hold the potential to be most effective in helping teachers consider aspects of teaching that center around MTT. Figure 23 shows that the major difference between coaching moves and conversations categorized as "moderately productive" and "highly productive" was that highly productive moves led to teachers making connections among all three MTT themes within a conversation.

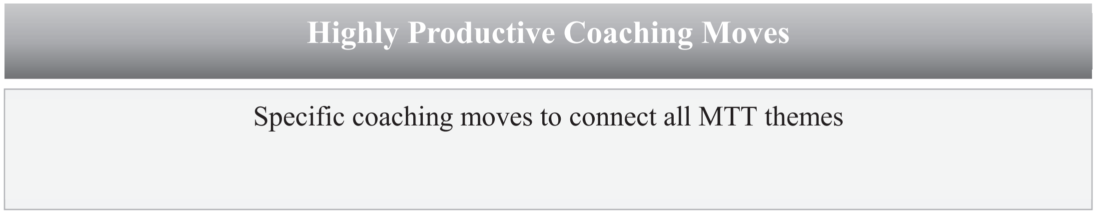

Figure 23. Highly productive coaching moves.

Specific Coaching Moves to Connect All MTT Themes

Of the 49 total coaching conversations across my data, only 4 conversations included coaching moves that helped teachers make links among all three MTT themes within a single conversation (see Figure 24).

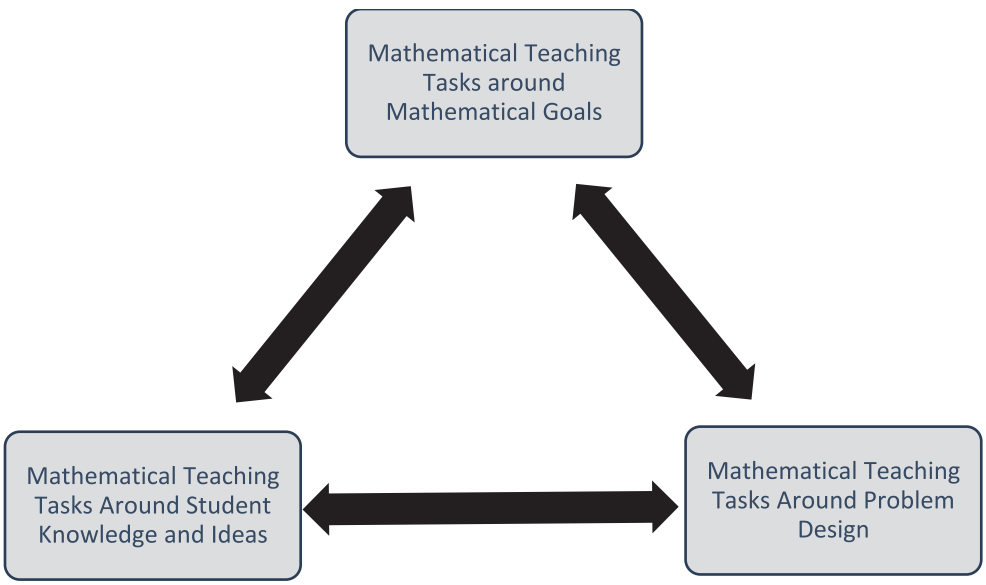

Figure 24. Connecting all three themes of MTT.

Not only did these two planning and two debrief conversations include coaching moves that made all three connection types, Planning and Debrief 2 also had some of the highest overall counts of MTT discussed within a single conversation (see Figure 18). This meant that the coaching moves in these conversations helped teachers consider a wider variety of topics around MTT than in nearly all of the other coaching conversations I observed.

Even in some of the “more productive” coaching conversations in Figure 18, coaching moves that made links among MTT themes often still led to brief exchanges. Although several conversations were highly productive, Planning and Debrief 2 offer a rich example as a counter point to some of these less productive instances of coaching. In this section, I provide several examples of the extended conversations around MTT themes that occurred throughout this coaching cycle.

Coaching moves connecting mathematical goals and problem design. Early on, the discussion in Planning 2 centered around understanding the connection between mathematical goals and problem design, as coaching moves focused on helping the teacher to articulate very clearly what her goals for the lesson were, and how to align the problem design with these goals. In the following excerpt, the teacher finished explaining the focus of the current chapter on graphing and interpreting data, and the coach followed up with a general question about problem design in turn 21.

> 21 Coach: All right. So what are you thinking of doing in the, have you already looked at it and decided what activities you feel are most beneficial?
> 22 Teacher: Well honestly, I knew you were coming so, I was hoping to…
> 23 Coach: Talk about that.
> 24 Teacher: Yeah.
> 25 Coach: All right.
> 26 Teacher: Get your opinion as well. Um, what I really would like to do, um I know it already gives like the whole template here, but what I’d really like to do is have the kids kind of create their own…
> 27 Coach: Mm-hmm.
> 28 Teacher: …on a separate piece of graph paper just because I think that will show me more than just filling in these blanks, because that almost provides too much of a template for them I think, because they already know we’ve got the labels, got our title…
> 29 Coach: Mm-hmm.
> 30 Teacher: But I want them to see, like place the numbers.
> 31 Coach: So you’re almost trying to get away from giving them so much support?

32 Teacher: Yeah.

33 Coach: Now that they can be more on their own…

34 Teacher: Mm-hmm.

35 Coach: …maybe think about it more deeply if they don't have everything right in front of them.

36 Teacher: Mm-hmm.

37 Coach: Okay.

(Planning 2 Transcript)

The question in turn 21 itself was not necessarily indicative of talking about mathematical goals, it was generic and asked about "activities," and the teacher could have simply focused on describing the problem design in this scenario. In this instance, the teacher may have provided an opening for the coach when she stated that she wanted the coach's opinion in the planning session as well in turn 26, and described how she planned to adapt the design from the textbook to increase the cognitive demand (Stein, Smith, Henningsen, & Silver, 2009) for her students ("appraising and adapting the mathematical content of textbooks" (Ball, Thames, & Phelps, 2008)) in turns 26 and 28.

Although the teacher was not directly talking about the mathematics, she may have implied a potential goal for this lesson on graphing in turns 26 and 28. The coach followed up by asking a second question that was more directly related to understanding the teacher's mathematical goals. Here the coach used the talk move of "restating" (Chapin, O'Connor, & Anderson, 2013) in turn 31 to offer her interpretation of what she heard the teacher describing as a goal of moving away from over-scaffolding and finding ways to promote productive struggle in her math lessons. By restating the teacher's goal in her own words, and posing it as a question back to the teacher, the coach attempted to clarify the teacher's goals for the lesson and verify that she understood the teacher's thinking accurately. This fits in with the notion of using patterns of questions and coaching moves to "focus" (Ball, Thames, & Phelps, 2008; Herbel-Eisenmann & Breyfogle, 2005) the teacher's attention to specific elements of her planning around MTT.

Gathering background information about the teacher's goals can offer insights to the coach that could potentially inform additional questions about problem design and how to set up the lesson in ways that address this goal. Although this goal (as examined in turns 31 through 35) was perhaps related more directly to mathematical teaching practices than the mathematical content, the conversation came back to talk around content-focused mathematical goals later on. In this first exchange, the coaching move of restating the teacher's goal in turn 31 helped the teacher articulate these goals in a way that informed much of the rest of the conversation. By framing the restatement as a question, it allowed the coach to ensure that the teacher's thinking remained focal in the conversation. Doing so builds a sense of equality in a teacher's work with the coach (Knight, 2004), and helps the coach maintain a responsiveness to the teacher's ideas (Ippolito, 2010), two practices promoted by the literature in Chapter 2. This coaching move of shifting the decision-making back to the teacher helped keep these principles as a central focus, pressing the teacher to examine her own practice through the use of a series of coaching moves, while productively engaging in talk around MTT.

Coaching moves connecting problem design and student thinking. After clarifying the mathematical goals for the lesson, the teacher explained her plan for the lesson design in the following exchange. This created a shift in the conversation toward thinking about problem design, and provided opportunities for the coach to ask questions related to MTT centered around problem design and set up in turns 41, 43, and 45.

38 Teacher: And what I thought about doing too is not on an individual but starting like small groups and just giving them the data, the information, and telling them to create the graph and basically just giving them, you know, “Use whatever supplies you need from the room,” and giving them a big sheet of paper, probably have several, because they’ll probably need that, and then seeing what they create as a group, like do they determine the correct labels?

39 Coach: Mm-hmm.

40 Teacher: …or something that’s…

41 Coach: Will they even…

42 Teacher: …appropriate.

43 Coach: …come up with a bar graph? Or would they maybe represent it differently if you just…?

44 Teacher: I think…

45 Coach: How are you going to present it?

46 Teacher: I guess I didn’t think about that, if it should, maybe I’ll say, “It has to be a bar graph.”

47 Coach: Okay.

48 Teacher: Because I think if I leave it too open, it might…

49 Coach: Well I’m just thinking if you say, “Here’s the data. Now I want you to show me how you would represent it,” it may not…

50 Teacher: Right.

51 Coach: …come out a bar graph.

52 Teacher: Right.

(Planning 2 Transcript)

The coach followed up the classroom teacher’s comment about “seeing what they create as a group” in turn 38 with a question asking the teacher anticipate the types of graphs students might come up with in turns 41-43, connecting the themes of problem design and students’ mathematical thinking. When the teacher did not immediately respond, the coach posed a follow up question asking how she would present the problem to students in turn 45, which may have pressed the teacher think about how the problem set up might influence the types of graph that students developed. When the coaching move of pressing the teacher to “anticipate” student thinking (Smith & Stein, 2011) did not move the conversation in the direction the question intended, this follow up move of posing a question about the problem design moved the teacher to consider the ways in which the set up can determine what students do mathematically. Again, the coach used a series of follow up coaching moves after to the initial question to focus the conversation in ways that help the teacher make these links among MTT themes, something that rarely occurred in less productive examples of coaching conversations in my data.

Coaching moves connecting mathematical goals and student thinking. At the start of the planning conversation, the teacher mentioned that students had worked with both picture graphs and bar graphs before, but it was unclear if students had experience with other types of graphs. It is possible the teacher is hesitant in turns 46 and 48, and perhaps is still uncertain of the goal for the lesson, and so in the next exchange, the coach turned the conversation back toward defining mathematical goals in turn 53.

> 53 Coach: And I don't know if that's important to you for them to make it into a bar graph or not.
> 54 Teacher: Um, you know…
> 55 Coach: Because I know in the lesson that's what they're showing.
> 56 Teacher: Right. But I mean, they know what a picture graph is and they know, they've seen data in other ways as well.
> 57 Coach: Mm-hmm.
> 58 Teacher: So maybe that would be good to kind of see what they gravitate towards too. Or maybe they'd do tally, tally chart.
> 59 Coach: Well, I guess it depends on what your objective is. If it's just to be able to interpret the data, make a graph and interpret it, and answer questions about it, problem solve based on the graph…
> 60 Teacher: Then it wouldn't matter what type.
> 61 Coach: Right.
> 62 Teacher: And that, yeah, that is my objective. I just want to know that they can interpret the data and turn that into a graph.
> 63 Coach: Mm-hmm.
> 64 Teacher: Not necessarily a certain type of graph.
> 65 Coach: So that might be…
> 66 Teacher: So yeah.

> 67 Coach: …interesting. I mean, if depending on the, like I said your objective. If it's not necessarily a bar graph that they need to have to do that, to interpret that data, then could be interesting to see what they come up with.
> 68 Teacher: Right. I think, yes, I think I'll do that.
> (Planning 2 Transcript)

The coach's initial statement in turns 53 and 54 examined how the mathematical goals were written in the textbook and pressed the teacher to consider whether she wanted to dictate the sort of graph students made or allow student choice in the graph design. Perhaps in order to help the teacher think through this decision about the problem set up, the coach stated multiple possible mathematical goals in turn 59, then shifted the decision back to the teacher in turn 67 to determine a focus. Unlike the first instance of posing a question about mathematical goals in this session, the teacher did not appear to have a clear focus as she did with a goal around mathematical practices, and here the coach did not use the move of restating as she did in turn 31 earlier in the conversation. Instead, the coach offered two possible alternatives in turns 59 and 67 as to potential mathematical content goals, one that sticks to the textbook's definition of a goal, and one that more broadly encompasses having students interpret data and use the data to create a graph.

This coaching move of offering choices here is not quite being directive and coaching by "telling" the teacher what she should do, yet providing limited choices did appear to steer the teacher's decision-making toward a more clearly defined mathematical goal. Despite offering choices at this point in the conversation, the coach still put the final decision making about goals back on the teacher. This is like the earlier excerpt in turns 21 through 37, where the coach attempted to keep the teacher's decision-making as a focus. Since the teacher appeared less certain in this later excerpt starting at turn 53, the coaching move of offering potential choices helped the teacher focus her goal and determine what sort of problem design matched this goal. When the coach poses this last coaching move, the teacher more clearly defined her mathematical goal in turns 62 through 64, and further conversation shifts back to the problem design in turns 69 through 74.

> 69 Coach: So what will you actually give them as far as the data?
> 70 Teacher: Um, so what I would give them is what the information it gives here. So if we're doing this rain one, I'd give them this whole thing. So let's give them, "Matthew measured the height of his plant once a week for four weeks. Describe how the height of the plant changed from May first to May twenty-second," and then with this data right here. So May first it was two inches, May eighth it was three inches.
> 71 Coach: Okay.
> 72 Teacher: And I mean it's going to be challenging for sure.
> 73 Coach: Mm-hmm.
> 74 Teacher: Um, but I mean that'll give me a good insight into who's…
> (Planning 2 Transcript)

This question about the data the teacher planned to use for the problem in turn 69 may have allowed the coach an opportunity to circle the conversation back to how the teacher planned to set up the mathematical problem ("presenting mathematical ideas" (Ball, Thames, & Phelps, 2008; Smith & Stein, 2011)), with a clearer focus on *how* data would be presented at the forefront of their planning, as evidenced by the teacher's remarks in turn 70.

The series of connected coaching moves, which began with restating mathematical goals in turn 31, led to conversation that connected multiple MTT themes. The coach's questions about mathematical goals led the teacher to consider *why* she considered adapting and modifying the problem design from the textbook presentation to meet her goal of promoting more student-led thinking. Clarifying the lesson goal also provided opportunities for coaching moves that helped the teacher anticipate the types of representations students might generate, and consider how this would could tie back to her goal of interpreting data on graphs. Although this second move connected problem design to student thinking, using coaching moves that linked these MTT themes to one another provoked teacher insights about possible problem design issues that led to a more clearly defined goal.

By posing questions and offering choices, the coach helped the teacher narrow the lens of the problem design and purpose while keeping the teacher's ideas and decision making a central focus. Again, these coaching moves worked in a "focusing pattern," similar to the patterns of questioning suggested by the literature (Herbel-Eisenmann & Breyfogle, 2005; NCTM, 2014) to engage students in mathematical thinking and discussion. The fact that the coach kept the conversation building around the teacher's ideas, and persisted in helping the teacher consider how to plan specific elements of the problem design *while* connecting all three MTT themes resulted in highly productive coaching moves in this instance.

Further coaching moves connecting mathematical goals and student thinking. The previous excerpts were not the only occurrence in Planning 2 of coaching moves that wove back and forth among the three MTT themes to help the teacher make connections in her planning. In a later episode, the pair had turned back toward talking about the problem design. In turn 113, the coach referenced one of the teacher's goals of "not taking over" student thinking from the earlier conversation. The coach used the coaching move of restating this goal to frame a follow up question, asking the teacher in turn 115 if she anticipated student struggle.

113 Coach: Right. It’s like you want to guide them there without really taking over their thinking and somehow get them to understand.

114 Teacher: That can be hard.

115 Coach: So do you think that could happen with making the graph?

116 Teacher: Um…

117 Coach: Or will that part be pretty easy for them, do you think?

118 Teacher: I think, honestly I think taking the data and putting it in, once they create the graph, I don’t think that part’s going to be the problem.

119 Coach: Okay.

120 Teacher: Like you know thinking through all that.

(Planning 2 Transcript)

In this exchange, the coach directly asked what the teacher would do if students struggled in turn 115. It was not clear whether the teacher anticipated much difficulty with the graph creation, as her statement in turn 118 suggests. The coach still followed up her initial question with a second question related to anticipating student struggle to press the idea further in turn 121.

121 Coach: I was just thinking, if it would be a problem, what could you, what could you say or do to get them to develop their thinking in how they can represent it or whatever? I don’t know.

122 Teacher: Right, um, well if they got to the point where they have the graph all done. Is that what you mean? So like they…

123 Coach: I mean even if they just had trouble making it. But you don’t envision that happening, is what you’re saying, right?

124 Teacher: Not really, but if they did, like for example if they didn’t have like the numbers on there, I might say, “Well, so how did they measure it? Well they measured it in inches.” And hopefully they would…

125 Coach: Mm-hmm.

126 Teacher: …be able to answer that and not me telling them. Um, and then how many inches in May? Or on May first? And they would say, “Two.” And I would say, “How would you show that on the graph if there are, you know, what would you need to put on the graph?”

127 Coach: Right. Okay

128 Teacher: And try to probe it that way. And then maybe asking them like if they are, if they don’t have these labels down here, May first, May eighth, May fifteenth, just asking them, “Okay, so we know how many inches, but how do we know when?”

129 Coach: Right.

130 Teacher: They have that many inches.

(Planning 2 Transcript)

Even if the teacher was not convinced students would struggle, when the coach followed up by asking what she could do if this occurred in turn 121, the teacher offered several hypothetical examples of questions she could pose and potential student responses in turns 24, 126, and 128 (planning to "ask productive mathematical questions" (Ball, Thames, & Phelps, 2008; Smith & Stein, 2011); "supporting productive struggle" (NCTM, 2014)). In this instance, the teacher tied these questions back to the data that students were presented with in the problem to address potential misconceptions students may have in interpreting the data.

Matthew measured the height of his plant once a week for four weeks. Describe how the height of the plant changed from May 1 to May 22.	May 1 May 8 May 15 May 22	2 inches 3 inches 5 inches 7 inches

Figure 25. Graphing Problem in Planning 2 (Dixon, Larson, Leiva, & Adams, 2012)

As shown in Figure 25, the problem for the lesson involved two sets of numerical data, the dates on which the plants were measured as well as the heights of the plants. In turns 126 and 128, the teacher offered examples of questions she would pose to help students consider what the numbers represented, what the labels on the different axes on the graph should have been, and consider what the information told them.

Smith and Stein (2011) refer to this move as "anticipating" student thinking to develop a plan of how to respond to different student ideas during the lesson by thinking through all possible student strategies ahead of time and planning possible ways to respond. In this instance, the coach's initial move of restating the mathematical goal in turn 113 and asking a question about anticipating student struggle in turn 115 were not enough to help the teacher anticipate. It was the follow up question, worded as a hypothetical, "What would you do if…?" in turn 121 that prompted reflection on specific actions the teacher would take if struggle occurred. This follow up moving of offering a hypothetical scenario to anticipate and address student confusion was a somewhat unique coaching move that resulted in the teacher planning an actionable "next step" for the lesson. Although the coach was able to help the teacher anticipate questions that she might pose to struggling students, the pair did not actually try out all of the ways students might solve the problem, the other crucial piece of what Smith and Stein (2011) refer to as "anticipating," and Costa and Garmston (2002) call the "rehearsal" part of the planning conversation. This coaching move was rarely evident when used in this way in any of my data, and it is unclear why this coaching move was so often omitted from planning and debriefing sessions.

Debrief coaching moves around mathematical goals- a unique occurrence. Much like its planning counterpart, Debrief 2 included several instances where coaching moves helped the teacher make connections among the three MTT themes, despite being a much briefer conversation than the planning (only 13 minutes in length). Posing questions around mathematical goals was not something that occurred often in debriefs, and even when it did the coaching moves rarely resulted in lead to specific teacher talk about how and to what extent the goals were met. I close this section of Chapter 5 with one example from Debrief 2 to share a counterpoint where the coach and teacher *did* discuss mathematical goals after the lesson. In the following excerpt, the coach led off with an open-ended question about the lesson, before shifting the focus toward the teacher's initial focus of students engaging in productive struggle in turn 9.

> 9 Coach: Good. Yeah I know at one point with the struggle they were having with making the graph, I mean you had even talked about that at one point, maybe giving them the template.
> 10 Teacher: Right.
> 11 Coach: So how do you feel about that now since you didn't?
> 12 Teacher: Right. I'm glad I didn't. Especially with the second table because they did get it.
> 13 Coach: Yeah.
> 14 Teacher: And they just needed that little extra time, so I'm really glad that I didn't. Even this table they're…
> 15 Coach: They're getting there.
> 16 Teacher: Teamwork is more of an issue I think here, but they will get it.
> 17 Coach: Right.
> (Debrief 2 Transcript)

The coach's open-ended question in turn 11 may have promoted reflection on an "in the moment" decision the teacher made as to whether to provide additional scaffolding when students were struggling to successfully create their graphs during the lesson. After the coach posed this question, the teacher reflected on how she saw this decision to adapt the difficulty of them problem design as an instructionally appropriate choice based on her observations of students during the lesson. In turns 12 and 14 the teacher stated that giving students extra time allowed several groups to make progress, but she did not offer specific evidence at this point as to how she knew that students were successful in creating the graphs without the template.

Perhaps the coach missed an opportunity to follow up with some sort of question that would have helped the teacher consider specific evidence she saw of student understanding at this point in the debrief. After some further conversation around goals and problem design, the coach came back to the other mathematical goal for the lesson and pressed further about student understanding. The coaching move in turn 70 pressed the teacher to consider the extent to which the graphs offered evidence that students met the mathematical goal. It is possible that the teacher was uncertain as to the coach's meaning from her response in turn 71, and then the coach restated the teacher's goal from the planning conversation in turn 72 in a way that may have helped to clarify and remind the teacher of this conversation.

> 70 Coach: Do you think these graphs alone are enough to know if they understand the concept?
> 71 Teacher: Of like creating a graph you mean?
> 72 Coach: Well, I mean, what was your ultimate goal? For them to be able to interpret it once it's made?
> 73 Teacher: Right.
> 74 Coach: Or to make it?
> 75 Teacher: Right. I think I would have to see more for sure.
> 76 Coach: Yeah.
> 77 Teacher: And I usually like taking notes, but there was so much involved and…
> 78 Coach: Yeah.
> 79 Teacher: There was just a lot.
> 80 Coach: There was a lot going on.
> 81 Teacher: There was a lot to probe today. There wasn't any time for me to go around and just like really listen and observe.
> 82 Coach: But as far as the task goes, think about if you had given them the worksheet page. Do you think they got a lot more out of this?
> 83 Teacher: Oh absolutely. Absolutely. If I would have just given them the paper, they would've been able to do it. There would've been some mistakes, but…
> 84 Coach: Right.
> 85 Teacher: There wouldn't have been that productive struggle that there was going on today, and I think they absolutely got a hundred times more than they would've with a worksheet.
> (Debrief 2 Transcript)

In this instance, the coach followed up with another clarification question about the goal in turns 72 and 74. As the coach posed these questions, there was evidence to support the teacher refining her thinking and clarifying her goals in turns 71-75 in response to these coaching moves. In this episode, the coach again pushed the teacher to reflect on what her mathematical goal was, making or interpreting graphs, even though this was discussed at length while planning. Although the teacher's responses indicated that some of her goals were left unmet at the close of the lesson (turns 79-81), the coach's final question in turn 82 helped the teacher to affirm her decision to adapt the problem design in order to promote productive struggle (lines 83 and 85).

Not only did the coach use multiple coaching moves in this episode, she also came back to asking about mathematical goals at multiple points during the debrief. This repeated focus of coaching moves on all three MTT themes helped the teacher consider ways in which the problem design influenced student thinking and the extent to which this design helped her to meet her goals. Perhaps a missed opportunity was for the coach to help the teacher generalize aspects of the problem design that could foster productive struggle in other lessons, or to consider what additional evidence of student understanding she needs to meet her second goal. Across my data, evidence of coaching moves that generalized ideas from debriefs in ways that could be applied to future planning were inconsistent. This is perhaps an important piece of evidence missing from many debriefs in my data that could potentially help to increase the productivity of coaching moves during debriefs. It is beyond the scope of my data to examine this possibility further.

Contextual Factors in Highly Productive Coaching Conversations

In examining the potential contextual factors that may have influenced these highly productive coaching conversations, some of the same factors as less productive conversations were still present. Figure 26 illustrates the contextual factors that were evident in the four most highly productive coaching conversations across my data.

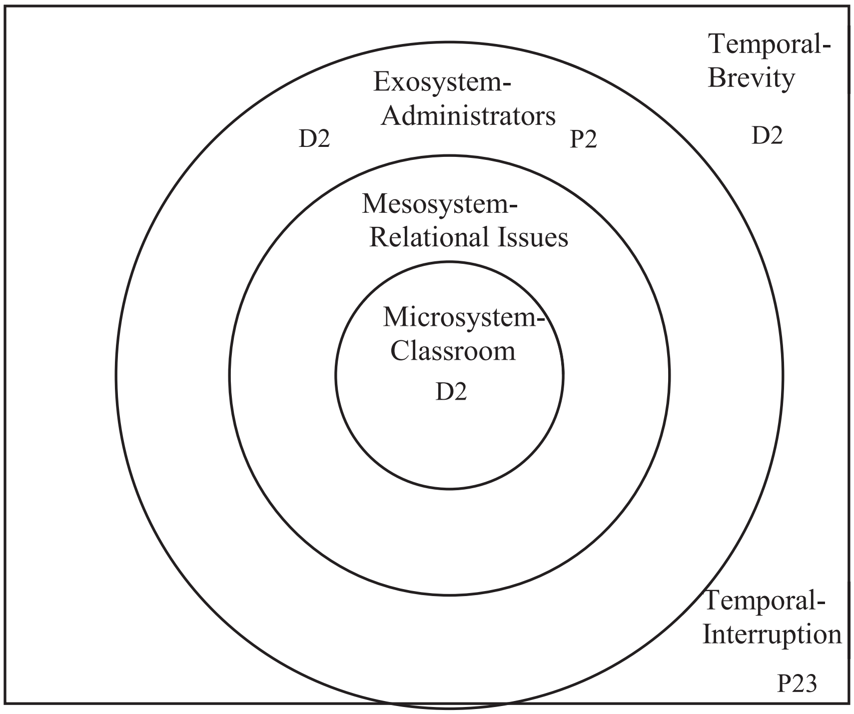

Figure 26. Contextual factors in highly productive coaching conversations.
Note: P2= Planning 2; P23= Planning 23; D2= Debrief 2

Microsystemic factors- classrooms. Much like some of the less productive coaching conversations, highly productive conversations included instances where factors that directly influenced the thoughts and actions of the teacher, such as the classroom environs. In Debrief 2, the conversation took place in the classroom while students worked independently on their math journal. The debrief was brief due to the limited time left in the lesson, and the teacher stopped the conversation at several points to address students who had questions or needed redirection while they worked independently. Despite this potentially negative mesosystemic factor, and despite the brevity of the conversation (13 minutes in length), the coaching moves in this session led to teacher talk around 7 MTT and made connections among all MTT themes. Additionally, the coach explained to me that the building principal wanted the coach to spend more time with teachers that were perceived as having higher needs for support, whereas the teacher in this cycle was a considered a stronger teacher (Interview with coach, Cycle 2). Even though this meant the coach and teacher did not collaborate as frequently, the planning and debrief with this teacher were among the most productive examples of coaching moves across my data. This indicates that the presence of perceived negative contextual factors are not enough to determine the productivity of coaching moves at times.

Mesosystemic factors- perceived positive teacher-coach relationships. It is of note that absent from Figure 26 is any evidence of mesosystemic factors that may have negatively influenced coaching conversations. The coaches and teachers in these four conversations appeared to have positive working relationships, as comments from both one of the coaches and one of the teachers helps to illustrate. After Debrief 2, the coach shared, “I feel like she is always open to it. We have a lot of conversations about math, and she’s always willing to have deeper conversations with me than a lot of other people about the content and the teaching and the math and what her kids learn and what they get from it” (Interview with coach, Cycle 2). In the instance of Planning 23, the coach described the relationship by saying, “It’s a good balance between me challenging her to try some new things, but the teacher directs this a little bit more. She has a desire to increase problem solving in her class as a whole… and so we’ve been talking about that throughout the content all year long,” (Interview with coach, Cycle 23).

At the end of the semester, the teacher confirmed this sort of back and forth relationship with her coach in our one on one interview. The teacher explained,

> She kind of lets me lead, however there's times where maybe I'll be like I need, I put it more on her, it's sort of my…she makes it more my decision I feel like. But usually we'll sit down, we'll kind of look at the lesson together and we'll sort of talk about like, I will usually talk about things I've done in the past that I feel like have been unsuccessful or successful with this particular concept, and then she'll talk about like different thoughts that she has, looking at different parts of the lesson, to make it meaningful.
>
> (Interview with teacher, Cycle 23)

This evidence suggests a mesosystem where there was mutual trust between the coach and teacher. The teacher viewed the coach as a "knowledgeable other" who could offer her insights and ideas about effective ways to develop mathematics lessons. When mesosystems between coaches and teachers are functioning well, it is possible that this could influence the productivity of coaching moves that help teachers attend to MTT and connect MTT themes in positive ways as well.

Despite evidence across my data that possible negative and positive contextual factors were present in these more productive coaching conversations, my data also provided evidence that the potential negative influence of some of these factors can be minimized by productive coaching moves. Even when microsystemic issues of the classroom were present, or time constraints and interruptions occurred, these coaching conversations maintained a focus around more distinct MTT, and coaching moves helped teachers make links among all three MTT themes despite the presence of such contextual factors. This suggests that when coaches incorporate certain features into their coaching moves such as using follow up moves to restate, clarify, offer choices, and help teachers anticipate student thinking, such factors may not negatively interact with the productivity of coaching conversations.

Conclusion

In Chapter 4, I shared big picture findings from my data with regard to the productivity of coaching moves across my data, including the development of a multi-layered definition of "productive." Throughout this chapter, I offered examples of coaching moves that represented a range of what I defined as "productive" coaching moves In Chapter 4 to better understand what it is that coaches can do to promote teacher's focusing around a range of MTT and making connections among MTT themes. In examining this range of productivity related to coaching, I observed several important things:

- Instances of less productive coaching often included less specifically worded coaching moves and often did not include follow up moves,
- coaching moves specifically worded around MTT, as well as the use of follow up moves, often resulted in more productive teacher talk around MTT,
- using debriefs as an opportunity to engage in planning "next steps" based around reflection on the MTT themes often resulted in more productive debriefs than those only focused around lesson reflection,
- posing questions around each of the MTT themes was by far the most prominent type of coaching move, particularly among moves that made links between and among MTT themes, and
- the types of follow up coaching moves in my data included: using the talk moves of restating and revoicing, asking questions to probe and clarify, offering choices, and pressing teachers to anticipate students' mathematical thinking.

These findings help to more fully address my first research sub-question, “What are the questions, statements, and moves that coaches make to support teacher thinking and instructional planning around mathematical tasks of teaching?” The examples shared from the moderately and highly productive coaching conversations in my data, in particular, indicated that coaches used a range of coaching moves that were categorized as productive. These moves tended to be worded in ways that were specific to the MTT the coaches sought to help teachers attend to, and often coaches were required to use a series of connected follow up moves after using one of the typical primary coaching moves as suggested by the literature (Figure 6, Chapter 4) to result in productive conversation around MTT. As the vignettes from the final section illustrated, when coaching moves worked to keep the ideas and voice of the teacher central to the decision-making and discussion, these moves helped the teacher to attend to MTT in ways that specifically and productively influenced their planning and instruction. Even within these highly productive examples in my data, there were perhaps missed opportunities for coaches to help teachers generalize their planning in ways that went beyond the scope of a single lesson, or to rehearse the mathematics ahead of the lesson. It is unclear from my data why these two coaching moves that the professional literature supports may have been less evident in the coaching conversations I observed.

In this study, I also sought to answer a second sub-question, “What are the contextual factors that influence the work of the coach with classroom teachers and how do such factors influence the moves that coaches make with classroom teachers?” In Chapter 4, I examined the types of contextual factors present across the coaching sessions at a broad level, noting the presence of microsystemic, mesosystemic, exosystemic, and temporal factors across my data, and I added several examples of exosystemic factors to the initial list I developed in Chapter 3. In this chapter, I re-examined the contextual factors as they occurred across the range of categories from less to highly productive coaching. The important findings from this work include:

- Each of the anticipated contextual factors from the list I developed in Chapter 3 appeared in my data, as well as two exosystemic factors that I had not considered, the influence of administrators and the intended curriculum,
- contextual factors that may be considered both negative and positive were present across coaching sessions (e.g. at times mesosystemic factors were seen as potential barriers, other times well-functioning relationships may have been positives), and
- the mesosystemic factor of "perceived relational issues" tended to be present more often in less productive coaching sessions, whereas more productive coaching sessions often had mesosystems that the coach considered functional.

These findings help to clarify my observations from Chapter 4 around the types of contextual factors that were present and in what types of coaching sessions they occurred.

Much of my work in this Chapter focused on the potential interplay between productivity of coaching and contextual factors, as it was a goal of this study to begin to better understand the influence various contextual factors may have on the work between coaches and teachers. There were several important findings in this chapter with regard to this interplay between contextual factors and the productivity of coaching moves, including:

- There was limited evidence that the exosystemic factors present in coaching sessions negatively influenced coaching productivity (with the exception of the intended curriculum in one session),

- although the mesosystemic factor of relational issues may have potentially interfered with the productivity of coaching moves in some sessions, there was evidence of at least one coaching cycle where productive coaching occurred in spite of its presence, and
- temporal factors such as scheduling and interruptions did not provide evidence of having a negative influence on the productivity of coaching, and there were instances where productive coaching occurred in spite of the presence of brevity as a factor.

Although it is beyond the scope of this study to definitely state that contextual factors directly impacted the productivity of coaching moves and conversations in certain instances, it is worth noting that as the productivity of the coaching moves and conversations increased, the potentially negative interplay of some of these factors appeared to be minimized in most instances across my data. Even in coaching cycles where the coach perceived relational issues with the teacher, such as in Planning and Debrief 1, when productive coaching moves were used, the teacher still attended to a range of MTT and made connections between themes in these conversations. In the vignettes from the highly productive coaching conversations in this chapter, Debrief 2 supports the idea that even the temporal issue of brevity can be overcome by productive coaching moves. The evidence presented here suggests that engaging in productive coaching moves to enact productive conversations around MTT with teachers matters more than the contexts within which these conversations occur. In Chapter 6, I discuss the potential implications of these observations on the work of mathematics coaches, those who support and train coaches, and the teachers with whom they work.

Chapter 6

Conclusion and Implications

This study was developed around the theory that productive coaching moves are those that help teachers attend to mathematical tasks of teaching (Ball, Thames, & Phelps, 2008), as these teaching tasks relate very closely to the research-based teaching practices endorsed in the current literature on mathematics teaching and learning (NCTM, 2014). In an examination of the current literature in Chapter 2, gaps identified in the research suggested that there is a need to know more about the types of coaching moves that are and are not effective in helping teachers to focus their planning and teaching in ways that are attentive to mathematical tasks of teaching. Studies suggested that coaches who incorporated a broader range of coaching moves were often more successful than coaches who used a smaller subset of moves (Huguet, Marsh, & Farrell, 2014), but little evidence was presented as to what these moves looked like in practice. The literature in Chapter 2 also left lingering questions as to how coaches attempted to negotiate challenges such as working with teachers who did not readily attend to MTT during coaching sessions, or how coaches worked within the presence of various contextual factors in attempts to engage in productive coaching with all types of teachers. This study attempted to address these gaps in the existing research in order to better inform the field about what aspects of coaching moves enacted during three part coaching cycles led to more and less productive instances of coaching.

In Chapter 4, one major finding was that coaching moves that helped teachers to attend to a range of MTT in ways that allowed teachers to make connections between and among three MTT themes was one important dimension of what makes coaching moves productive. In Chapter 5, a further finding was that the initial definitions of "productive" as helping teachers attend to a range of MTT and to make connections between and among MTT required multiple layers of work on the part of the coach and teacher. One overarching conclusion from this study then, is that coaching moves alone do not determine the productivity of the conversation. The phrasing and purpose of coaching moves, and attending to the responsiveness of the teacher's replies in order to engage in meaningful work around MTT, also play a part in determining the productivity of coaching moves.

Another observation from Chapter 5 was the examination of the types of coaching moves that were categorized as moderately and highly productive. In most of the vignettes and examples in productive coaching conversations, coaches used a series of connected coaching moves to help teachers reflect more deeply around MTT and connect MTT themes. In comparing the less productive and highly productive examples of coaching moves, these differences became consistently apparent. Therefore, a second overall conclusion from this study is additional consideration of what constitutes "productive coaching moves" to include more than stand alone questions, suggestions, or ideas. Similar to the work of Herbel-Eisenmann and Breyfogle (2005) around patterns of productive questioning, productive coaching also includes the patterns in which coaches string a series of coaching moves together to promote teacher focus around MTT.

A final area of reflection from Chapters 4 and 5 was the presence of contextual factors throughout all categorizations of coaching with regard to productivity. There were instances of microsystemic, mesosystemic, exosystemic, and temporal factors present in the less productive, linear, and moderately productive coaching conversations. In the highly productive coaching conversations, there was evidence of all types of factors except negative mesosystemic factors, indicating that productive coaching can occur despite the presence of a range of contextual factors. A final conclusion for this study then, relates to the idea that it may not be possible to determine the productivity of coaching work by examining contextual factors outside of the context of coaching conversations themselves. The presence of contextual factors did not consistently act as a definitive predictor of the productivity of coaching moves, nor in all instances was the presence of contextual factors a negative influence on the work of coaches and teachers.

Coaching Moves Are Not Inherently Productive or Unproductive

This study began with an intended focus on examining these *moves* as the central pivot point upon which productive or unproductive coaching conversations were enacted. Based on the analysis presented in Chapters 4 and 5, this was an overly simplified view of what it was that led to productive coaching. As Chapter 2 discussed, much in the way that teaching is a complex process (Cochran-Smith & Lytle, 1990), instructional coaching is a similarly complex role to understand (Anderson, Feldman, & Minstrell, 2014; Mangin & Stoelinga, 2011). Examining coaching moves in isolation of the broader context of the coaching conversation, as well as the role that both actors (the coach and classroom teacher) played in enacting the conversation, was as critical to determining the productivity of the coaching moves as the moves themselves. Alone, coaching moves were neither inherently productive or unproductive, it was how they played out within the conversation, and how each of the actors reacted to these moves, that determined their effectiveness in focusing the discussion around MTT. This conclusion suggests that coaches need to develop certain skills that can help them enact coaching moves productively, including: 1) the ability to foster two-way communication and participation from classroom teachers, 2) a knowledge of the patterns of interactions that these two-way communication typically result in during coaching conversations, and 3) an understanding of the types of follow up coaching moves that can increase teacher focus around MTT.

Two-Way Communication and Participation is Necessary

In the coaching conversations categorized as less productive in Chapter 5, both the coach and the teacher played a role in the lack of focus around MTT. At times, the coach worded coaching moves in ways that did not specifically focus the talk toward MTT. With certain teachers, this did not help them attend to particular MTT as a result. Even when coaches worded coaching moves in ways that more directly connected to MTT, there were instances in less productive conversations where teachers did not always attend to these intended foci. This suggests that both the coach and classroom teacher play a part in determining the productivity of coaching moves. When coaches word moves in such a way that it is unclear what they are hoping to help the teacher notice about their planning and teaching, or when they are specific and teachers fail to recognize this, both parties can be at fault for the failure of the coaching move to result in talk around MTT. Hubley (1993) described communication as a “complex process,” and Prozesky (2000) suggested that the best way for teachers to overcome barriers to two-way communication is by getting regular feedback from the receiver (the students) to ensure they are understanding the conversation. Similarly, coaches must provide teachers with opportunities to share their ideas and interpretations throughout the conversation to ensure they are understanding and participating actively in the conversation.

It is possible in the vignettes provided in Chapter 5 that the coach was not responsive to the teacher's remarks in ways that could have increased the productivity of the conversation. In the professional literature presented in Chapter 2, Campbell, et al. (2013) and Knight (2004) referred to this responsiveness as "active listening." In his study of literacy coaches, Ippolito (2010) discussed the extent to which coaches were "responsive" to teachers' ideas and concerns during coaching conversations as influencing how well teachers were willing to engage in reflective conversations about reform-oriented practice with coaches. In "linear coaching conversations," an overreliance on coaching tools such as pre-conference and debrief "protocols" may have limited the flexibility and responsiveness needed to make meaningful connections between and among MTT in the moment when working with teachers. If coaches feel tied to a script, they may not be able to react to unanticipated comments by teachers or recognize and act on potential opportunities to push teacher thinking further about a wider range of mathematical tasks of teaching in their planning and reflection. Even when this was not the case, coaches did not always enact coaching moves in ways that promoted deeper and more detailed reflection on a range of MTT productively. In Chapter 5's examination of the range of coaching conversations from less to more productive, where the conversation went *after* the initial coaching move sometimes mattered more than the initial coaching move itself in fostering productive talk around MTT and connecting MTT themes.

It was also evident from the findings in Chapter 5 that teachers played an important role in how these coaching moves were enacted. In more productive conversations, when generic moves were used, teachers still tended to focus their talk around MTT. This leads to a question as to why less specific coaching moves resulted in different outcomes across different categories of coaching conversations. It is possible that teachers who worked with coaches more frequently began to anticipate the importance of talking about MTT without as much direction from the coach. If one goal of coaching is to help teachers learn a thought process about teaching mathematics in reform based ways, the findings in this study suggest that some teachers were learning this thinking process through the reflective coaching conversations they had as part of participation in the three part coaching cycle. In these instances, the coach acted as more of a facilitator to help the teacher think through all aspects of the lesson and try to make connections among MTT themes throughout. When coaches shared with me that teachers may have been less familiar with the three part coaching cycle, it is possible that they were likewise less familiar with what productive coaching conversations typically try to focus on. Such teachers appeared to need more guidance from the coach to develop facility for thinking and noticing in this way, as well as a sense of purpose in doing so. Helping teachers develop this way of thinking may require teachers to reconceptualize what it means to teach and learn mathematics effectively (Ball & Cohen, 1999).

Developing the Noticing and Professional Vision of Teachers and Coaches

Sherin and van Es (2009) developed a framework for examining “teaching noticing” and “professional vision,” or a teacher’s ability to attend to and interpret various elements of a mathematics lesson. Their framework focused around two elements: selective attention and knowledge-based reasoning. In their research, Sherin and van Es found that teachers focused their attention on a range of lesson elements during the complex act of teaching, such as student behaviors and engagement. The researchers used a professional learning model of video clubs to help shift teacher noticing toward the mathematical ideas of students during the lesson. They described knowledge-based reasoning as a teacher's ability to notice "…based on his or her knowledge of the subject matter, knowledge of the curriculum, or knowledge of students' prior comments" (p. 22). When coaches attempted to help teachers attend to MTT and to make connections between and among MTT themes, this work similarly sought to shift the professional vision of teachers toward noticing these mathematical tasks of teaching and the interplay among them.

Sherin (2001) and Jaworski (2001) both described these shifts as helping teachers learn to attend to student thinking and learning in ways that can transcend planning for or reflecting on a single lesson. When coaches help teachers learn to notice MTT and connect MTT themes, they can promote shifts in teachers' thought processes for planning and teaching mathematics at a broader level. At times, the coach may need to use more explicit means, such as specifically worded coaching moves and follow up coaching moves, in order to do so effectively. If the goal of instructional coaching is to help teachers learn to successfully plan for and teach mathematics in reform-based ways, that are responsive to student thinking and knowledge, then coaches must help teachers consider ideas that transcend a single lesson. Since coaches face many challenges in working with all teachers in three part coaching and in doing so frequently, coaching moves that help teachers make these sorts of shifts in their professional vision can potentially influence teacher practice more effectively.

If coaches must help teachers learn to notice what is important to teaching and planning mathematics in reform-oriented ways, then it is critical for coaches to understand how and when to help teachers make these shifts as they collaborate with them during the three part coaching process. Therefore, another layer of noticing that must be developed is that of the mathematics coach. Coaches must learn to notice teachers as learners during these conversations, particularly when working with teachers who may be less aware of attending to MTT and reform-oriented mathematical teaching practices, or aware of what coaches are trying to model in trying to develop thought processes for planning and teaching mathematics with classroom teachers.

Much like teachers must develop practices to help them orchestrate productive mathematical discussions with students (Smith & Stein, 2011), coaches must learn to set goals for the connections and generalizations they want teachers to make during the coaching session, and must anticipate what teachers will and will not notice and say during these talks. Similar to the planning sessions that coaches do with teachers to anticipate student thinking and strategies during the lesson, coaches may need to plan ahead of their work with teachers in order to anticipate how to help teachers engage in productive coaching conversations. Planning this work ahead of the coaching cycle can provide the coach with opportunities to prepare coaching moves during the session that are designed in ways that help teachers begin to notice certain features of their planning around MTT, and that help them make connections to their broader thinking and teaching processes.

Several studies in Chapter 2 examined the need for coaches to develop "consumers of coaching" (Yopp et al., 2011), who understand the purpose of coaching and how to utilize coaching moves to improve their practice as teachers, as well as to develop a shared sense of purpose and collaborative control between the teacher and coach (Secada & Adajian, 1997). Similarly, in their study of interpersonal communication, Wish and Kaplan (1977) found that cooperation between individuals participating in a dialogue tended to be highest when the goals and beliefs of both parties were in alignment. They also described five dimensions of two-way conversations:

- Cooperative and friendly versus competitive and hostile,
- Intense versus superficial,
- Dominance versus equality,
- Formal and cautious versus informal and open, and
- Task oriented versus non-task oriented (p. 244).

This study mirrored the findings in Chapter 5, that when teachers appeared uncertain of the role of the coach and the coaching cycle as a process, conversations tended to be less productive. When coaches led unbalanced conversations, when they failed to intensify the talk around relevant topics that helped teachers notice features of their planning and teaching practice, and when they were unable to maintain a task oriented focus with the classroom teacher, the productivity of the conversation likewise declined.

These findings suggest that it is critical for coaches to help teachers understand the purpose of coaching conversations, and help teachers align their goals with those of the coach to maintain a focus around MTT during planning and debriefing conversations. Doing so can address challenges left unanswered by the existing literature in Chapter 2, such as what to do when teachers fail to attend to MTT or do not engage in reform-oriented planning and teaching as a result of work with a coach (Olson & Barrett, 2004). Developing the ability of the coach to notice opportunities to provide this support to teachers, and developing coaching moves that the coach can use to effectively help the teacher notice mathematical tasks of teaching in their practice, are necessary skills of effective mathematics coaches.

Patterns of Coaching Moves Matter

Another observation in examining the findings of Chapters 5 and the range from less to more productive coaching conversations was not only a difference in the specificity of the wording of coaching moves around MTT, but also in the patterns of coaching moves used. Coaches engaged in a variety of patterns, some that resulted in more productive work around MTT with teachers than others. Recognizing both the patterns of coaching moves that tend to lead to productive coaching, as well as the types of follow up most that foster these productive patterns during substantive conversations with classroom teachers, is another central idea from this study.

Defining Productive Patterns of Coaching Moves

In less productive coaching conversations, coaches often did not persist in helping teachers to attend to particular MTT when an initial coaching move did not shift the conversation in that direction. Although the teacher shared a responsibility in engaging in conversations for them to be productive as well, it is possible that at times they may not have known how to do this after a single coaching move was posed. In contrast, conversations categorized in Chapter 5 as moderately or highly productive tended to include a series of connected “follow up” coaching moves. These moves were aimed at probing, clarifying, and refining the teacher’s thinking around a particular MTT or a connection between MTT themes. Such follow up moves align with the types of questions (Boaler & Brodie, 2004) and patterns of questioning described in Chapter 2 as being central toward fostering productive teaching practices around posing purposeful questions and engaging students in mathematical discourse (NCTM, 2014). Even when teachers did not initially respond in detail to an initial coaching move, these follow up moves typically helped teachers shift their attention toward MTT throughout the conversation.

These connected series of moves help to facilitate dialogue that centered the teacher's attention around particular aspects of the lesson as it relates to MTT, in ways that are parallel to the focusing pattern of questioning described by Herbel-Eisenmann and Breyfogle (2005). The authors explained that productive questioning goes beyond asking good individual questions. Rather, it was the use of questioning patterns that facilitated conversation where students were encouraged to clearly communicate their thinking and reasoning, and solving problems in a range of ways that matters. Similarly, when coaches use follow up coaching moves, whether they are probing or clarifying questions, talk moves, or additional MTT-specific questions, ideas, and suggestions, these additional supports helped teachers to more clearly communicate their thinking around MTT. This type of focusing pattern in coaching moves offers a powerful insight to help answer lingering questions left by the research in Chapter 2 as to how coaches using coaching moves effectively. Using focusing patterns of coaching moves allows them to be more responsive in the two-way dialogue with teachers, in a way that strives to keep the teacher's thinking and ideas central to the conversation, while directing the focus around developing the teacher's professional vision around MTT.

Figure 27 illustrates the potential patterns of interactions that tend to occur between coaches and teachers during coaching conversations. The pattern begins with the coach posing either a generic or specific coaching move, and, depending on the response of the teacher and the ability of the coach to "notice" where the teacher as a learner is in their awareness of the coaching move's intent, the coach then shifts to a follow up move that is generic or specific in nature, or they move on to another topic of conversation.

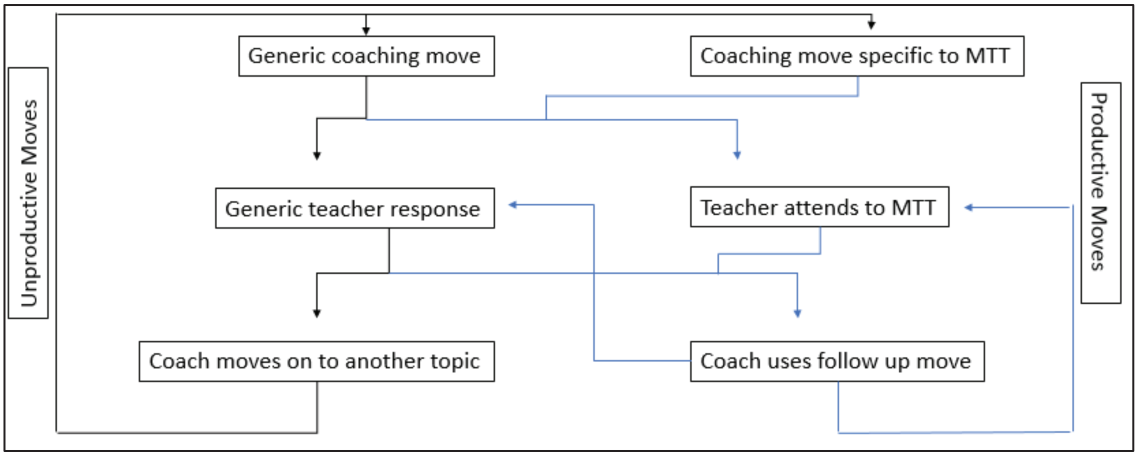

Figure 27. Potential patterns of coaching interactions between coaches and teachers.

This figure helps to further illustrate the concluding idea that coaching moves are not inherently productive or unproductive on their own, it is what happens next that matters. Patterns of coaching moves that tend to remain on the left side of the diagram in Figure 27 typically result in less teaching noticing and work around MTT that patterns of coaching moves that tend toward the right side of the diagram. When an initial coaching move, whether worded generically or more specifically around MTT, resulted in a generic teacher response, the talk was unproductive. Even when the coach used follow up moves (a shift to the right side of the figure) and the teacher still responded generically, eventually the coach would move on to another topic, which again resulted in unproductive talk. It was only when the use of coaching moves resulted in the teacher attending to MTT, and typically when the coach also used follow up moves to probe the teacher's thinking and to help them clarify the MTT they were discussing, that coaching moves resulted in productive mathematical talk.

Much as Lampert (2001) described the practice of teaching as the interactions between teacher, content, and students, coaching is a process that relies on both the actions and interactions of the coach and the classroom teacher. It is within the problem space of these interactions that the productivity of coaching moves, and as a result the overall coaching conversation, are determined. Figure 28 attempts to illustrate what it looks like for the work of the coach in these coaching sessions to attempt to help the teacher attend to the interactions between the teacher, content, and the student in planning for mathematics instruction.

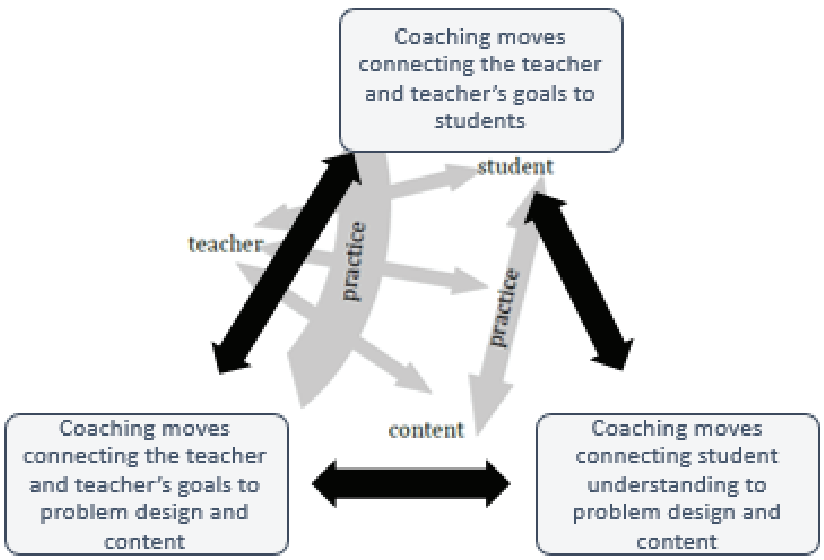

Figure 28. The complexity of coaching moves as it relates to Lampert's triangle (adapted from Lampert, 2001, p. 31)

The overlay of the coaching triangle over Lampert's helps the reader to visualize the numerous layers a coach must consider as they negotiate these interactions with classroom teachers. Much like the arrows in Figure 27, those in Figure 28 demonstrate the range of places the conversation can go, depending on the move of the coach, as well as the reaction of the classroom teacher. Whether the coach begins with a generic or specifically worded coaching move, it is the response of the classroom teacher that determines the continued direction of the conversation. When teachers attend to MTT, the coach's goal in using a particular coaching move is met. Whether it is met to their satisfaction or the coach attempts to help the teacher reflect further may determine the next move that they make (moving on to talk around a different MTT or continuing to focus on the current MTT) in this pattern of interactions.

Similarly, when teachers do not respond to coaching moves by attending to MTT, the coach may either follow up with another move that continues to encourage the teacher to attend to a particular teaching task, or they may use a coaching move that shifts the conversation in a different direction. As this process repeats iteratively throughout a coaching conversation, the more these interactions lead to a teacher attending to a range of MTT, the more productive the conversation becomes. When either the coach or the teacher is unable to bring the focus of the conversation toward MTT, the productivity of the coaching move and the overall coaching conversation tended to deteriorate. Throughout Chapter 5, it was conversations where this back and forth responsive coaching conversation occurred that coaching moves were most productive.

Categorizing Follow Up Coaching Moves

The coding and analysis of coaching moves in Chapters 4 and 5 was based on the types of coaching moves the professional literature suggested were the most effective for mathematics coaches to use (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013). These moves were categorized broadly in Chapter 2 as: 1) posing questions, 2) sharing ideas and suggestions, 3) actively listening, and 4) promoting analysis of student thinking and data. In reflecting on the discussion of the examples and types of follow up moves used by coaches in moderately and highly productive coaching conversations in Chapter 5, common “moves” appeared in these follow up actions of the coach. Typically, coaches asked probing or clarifying questions (Boaler & Brodie, 2004), pressed teachers to explain their reasoning (Boaler & Brodie, 2004; Chapin, O’Connor, & Anderson, 2013), and used the talk move of “restating” (Chapin, O'Connor, & Anderson, 2013) to ensure they were interpreting teacher remarks accurately as follow up coaching moves to foster productive patterns of coaching interactions.

Table 23 provides a revised list from the one presented in Chapter 4 (Table 9) to illustrate the types of coaching moves that can lead to productive talk around MTT and MTT themes.

Table 23

A Revised List of Productive Coaching Moves Around MTT Themes

Primary Coaching Moves

Around Mathematical Goals	Around Mathematical Problem Design	Around Student Mathematical Knowledge
• Posing questions around mathematical goals • Offering ideas and suggestions around mathematical goals • Prompting use of data/student work analysis to inform mathematical goals	• Posing questions around mathematical problem design • Offering ideas and suggestions around mathematical problem design • Prompting use of data/student work analysis to inform problem design	• Posing questions around students' mathematical knowledge or ideas • Offering ideas and suggestions around students' mathematical knowledge or ideas • Prompting use of data/student work to analyze students' mathematical knowledge or ideas

Secondary (Follow Up) Coaching Moves

- Posing clarifying questions
- Posing probing questions
- Pressing the teacher to explain their reasoning
- Restating the teachers ideas to affirm or clarify
- Using another "primary" coaching move

Unlike the initial, or primary, coaching move, these follow up moves were not always directly tied to a specific MTT theme as they occurred in conversations, but focused instead of helping the teacher more fully develop their ideas around particular MTT. At times, the coach also used another "primary" coaching move as a follow up when an initial move did not result in the teacher attending to MTT. Fullan and Knight (2011) described these the need for coaches to provide structures that help to support collaborative discussion. Using follow up coaching moves to support and scaffold conversations with classroom teachers can ensure that teachers attend to MTT and make deeper connections between their goals, student thinking, and problem design in their planning. In Chapter 2, the existing literature pointed toward a need to develop a better understanding as to how coaches negotiated times when teachers did not attend to MTT during coaching sessions or employ reform-oriented practices in their teaching (Olson & Barrett, 2004). Helping coaches recognize the types of follow up moves that can foster productive dialogue and incorporate them into their coaching practice would support the development of effective coaching practice that avoids these sorts of coaching pitfalls with classroom teachers.

Principles to Actions described learners as needing experiences that help them to "construct knowledge socially, through discourse, activity, and interaction related to meaningful problems," as well as to "develop metacognitive awareness of themselves as learners, thinkers, and problem solvers, and learn to monitor their own learning and performance" (2014, p. 9). This is a close parallel to the goal of the three part coaching cycle as a dialogic mechanism through which the coach and teacher discuss problems and ideas related to teaching mathematics. Through the use of productive coaching moves, the coach can help the classroom teacher begin to shift their professional vision toward noticing and attending to MTT, and to seeing the connections between and among the overarching MTT themes in ways that can increase student understanding and learning of mathematics. By helping teachers to attend to these teaching tasks, over time coaches can help teachers to increase their metacognitive awareness of these tasks in ways that permeate their planning and teaching beyond their work with the coach. Recognizing that it is not just about individual moves, but attending to what teachers say in response and using appropriate follow up coaching moves to deepen the dialogue, is a critical feature of productive coaching that coaches and those who support and train coaches need to incorporate in order to help teachers achieve such goals.

Why Contextual Factors Matter

A final observation related to the findings from Chapters 4 and 5 is in regard to the presence of contextual factors across all categorizations of coaching conversations, both those that were less productive as well as those that were more productive. Chapter 2 illustrated the dearth of available literature on the sorts of contextual factors that are present within the work of mathematics coaches as they enact three part coaching cycles with classroom teachers. In Chapter 5, evidence of contextual factors was present at nearly all levels of the ecological system developed by Smith, Hayes, and Lyons (2016) and adapted in Chapter 3 to include temporal factors. Since contextual factors were nearly always present in coaching conversations, it is important to understand how these factors potentially influenced the productivity of coaching and what, if anything, coaches did to maintain productive and substantive coaching conversations in the presence of this range of factors. Not all of these factors are within the control of the coach (or the classroom teacher in some instances), therefore it is important to determine how contextual factors and the productivity of coaching moves are interrelated.

Often, microsystemic, exosystemic, and temporal factors are beyond the control of the coach. Despite this, developing an awareness of the presence or absence of such factors, and considering ways to minimize the influence of these factors, can help coaches maintain productive conversations with classroom teachers. For example, microsystemic factors, such as the influence of other teachers or the classroom environs on the classroom teacher, are perhaps beyond the ability of the coach to influence. Being aware of these microsystems as a potentially positive or negative influence can help coaches to plan for work with teachers that helps them to see how work with a coach can benefit their teaching practice.

Influence of Exosystems on Planning

Exosystemic (or external, district level) factors were present in some coaching cycles in Chapters 4 and 5, but perhaps had the least direct impact on the productivity of coaching conversations. Most of the time, other contextual factors seemed to matter more than the influence of external factors such as administrators or the intended curriculum. Although working within the intended curriculum that the district expects teachers to follow afforded some coaches less opportunities to help teachers attend to many MTT, other times the curriculum provided opportunities for the coach to ask teachers specific questions about their mathematical goals and problem design as they related to the lesson in the textbook, and helped teachers consider ways to adapt these lessons to better align with their goals and the needs of students. This factor in and of itself is neutral in nature, and is not inclined to adversely affect the productivity of coaching moves. However, Hiebert et al. (1997) and Stein et al. (2009) suggest that not all mathematical problems provide equal opportunity for students to engage in problem solving and conceptual learning. Recognizing that certain lessons may afford less opportunities than others to help teachers develop a professional vision around a broader range of MTT could help coaches to consider whether scheduling coaching cycles with teachers for these sorts of lessons. If a coach is aware of curriculum issues, they can work with classroom teachers to reschedule coaching cycles around lessons where such opportunities *are* present.

Chapter 5 offered some limited evidence of administrative influences on who coaches were asked to work with and how often, but these exosystemic factors did not appear to detrimentally influence the productivity of coaching moves in those coaching cycles where they were evident. Despite the fact that studies in Chapter 2 suggested that administrators could negatively influence a teacher's perception of working with a coach (Anderson, Feldman, & Minstrell, 2014), and although the administrator can promote or discourage the work between coaches and particular classroom teachers, this factor did not appear to hinder the work of coaches in this study. Since these factors are further removed from Lampert's triangle (Figure 8, Chapter 4), it is possible that they have less influence on the productivity of coaching moves and conversations than contextual factors that are more directly related to the teacher, content, student relationship (2001), such as the micro- and mesosystemic factors present for the coach and teacher.

Influence of Microsystems When Planning

With regard to microsystemic factors present across coaching sessions in Chapter 5, there were few instances where the classroom was found to be a factor, and in one instance this factor was coded in a linear coaching conversation, yet in the other it was coded in a highly productive coaching conversation. Although additional evidence would need to be collected to better understand the potential interaction of the classroom as a microsystemic factor on coaching sessions, the evidence presented in Chapter 5 was inconclusive that this factor negatively influenced the work between the coach and teacher. A more prevalent microsystemic factor present throughout the analysis in Chapter 5 was the influence of other grade level teachers on the coached teacher. This factor was only present in unproductive and moderately productive coaching conversations in Chapter 5. This may suggest that, although weak relationships between the coach and other teachers on a coached individual's team may interact with the productivity of coaching moves, in some instances the coach still engaged in substantive conversation around MTT with the classroom teacher. If the types of coaching practice described in this chapter are employed in work with teachers who have microsystemic factors present, it is possible the coach can still engage in productive coaching work around helping teachers attend to MTT in their planning and teaching.

Influence of Temporal Factors When Planning

Temporal factors were present across all categories of coaching moves in Chapter 5. When instances of interruptions occurred during coaching conversations, the coach or teacher nearly always redirected the conversation back toward MTT after the disruption ended, indicating that this factor did not seem to influence the productivity of coaching moves or conversations. Despite a discussion of the existing literature in Chapter 2 that hinted at the possibility of scheduling being a potentially hindering factor to deep coaching work (Bean et al., 2010; Matsumura, et al., 2010), coaches in this study nearly always scheduled both planning and debrief conversations. For the most part, this minimized any potentially negative interplay that scheduling may have had on productive coaching. There were only two debriefs that occurred via email, and only one coaching session that was cancelled and never rescheduled across the data. It is possible that when coaches scheduled with classroom teachers, the presence of an observer may have led to an overrepresentation as to how frequently complete three part cycles were scheduled compared to what was typical for coaches and teachers in some instances.

The temporal issue of brevity was present across many coaching conversations in Chapters 4 and 5. In some instances, as the data analysis in Chapter 4 supports, shorter debriefs did not include as much teacher work around MTT and sometimes fewer connections were made between or among MTT themes. Debrief 2 stood in stark contrast to this, as a brief but highly productive example of a coaching conversation illustrated in Chapter 5. Although brief conversations were not always productive, Debrief 2 suggests that it is possible for coaches and teachers to work productively despite the factor of brevity when the conversation is focused, and both the coach and teacher maintain a dialogue centered around MTT themes. If coaches can use a range of primary and secondary coaching moves, and help develop teachers' professional vision around MTT, productive conversations can occur within more limited time constraints for coaching sessions. Planning for these conversations ahead of meeting with the teacher could help coaches to better anticipate the sorts of moves that would be most likely to result in productive conversations around MTT themes with teachers.

Influence of Mesosystems When Planning

Mesosystemic, or relational, factors had the most potential influence on the productivity of coaching conversations in Chapter 5. When there were issues, either perceived relational problems between the coach and teacher, or a new coaching relationship was developing, these factors may have interfered with the productivity of the coaching conversation. Perceived issues with mesosystems tended to appear more frequently in less productive coaching sessions, and teachers with whom coaches stated they had positive mesosystemic relationships often tended to engage in more highly productive coaching work. Since mesosystemic factors are those that directly relate to the coach-teacher relationship, these are also perhaps the factors that coaches can have the most direct influence on.

If the coach-teacher relationship is new, coaches have a responsibility to help the teacher understand the purpose and goals of the coaching cycle, and to become effective consumers of coaching (Yopp, et al., 2011). Teachers who are new to coaching may not currently have a professional vision that includes noticing of MTT and MTT themes. Coaches need to be aware of this and develop their own coach noticing when they are planning ahead of the three part cycle so that they can facilitate discussion that helps teachers to develop this awareness in teachers. The way coaches word coaching moves matters in helping to build this understanding, and being prepared with a series of potential follow up moves to focus the conversation when initial moves are not effective in helping teachers attend to MTT may be needed.

Similarly, when coaches work with teachers with whom they perceive relational issues, the patterns of coaching interactions they use during coaching sessions matters. When coaches phrase coaching moves generically, do not follow up with a focused series of moves to probe and clarify thinking, or create an imbalance in the conversation to try to maintain a focus around MTT, they may be unable to help the teachers learn to notice these features of thinking about planning and teaching math. In Chapter 5, Planning and Debrief 1 offered a counterpoint to many of the less productive instances of coaching conversations where mesosystemic issues were present. In this coaching cycle, the pattern of coaching moves included a consistent use of follow up moves and productive patterns of coaching moves throughout the conversation, helped the teacher attend to more MTT and make connections among MTT themes despite the presence of a potentially negative mesosystemic factor.

Based on the analysis of coaching moves and their interplay with contextual factors in Chapter 5, it seems that coaches can in fact have productive conversations despite challenges to the relationship. In the current literature presented in Chapter 2, there was evidence to suggest that positive relationships did not always result in productive coaching (Murray, Ma, & Mazur, 2008), but the findings in Chapter 5 suggest that it is possible for productive coaching to occur without the presence of a strong mesosystem as well. In the instance of coaching cycle 1, the coach helped the teacher to clarify and refine her mathematical goal, and focused subsequent coaching moves on helping the teacher connect ideas and observations related to student thinking and problem design back to this goal. Keeping the teacher's voice central to the conversation (Knight, 2008), while maintaining a balanced dialogue, allowed the coach opportunities to introduce talk around a range of MTT and to connect multiple MTT themes. In such instances, coaching moves that are specific and well planned can help the coach facilitate conversations that focus a teacher's attention toward MTT when the teacher otherwise might not go there on their own.

More often, however, moderately and highly productive coaching conversations were ones where the coach reported positive mesosystems with the classroom teacher, so it is important that coaches do not dismiss the need to build up these relationships with classroom teachers. The category "highly productive coaching conversations" was the only one across Chapters 4 and 5 where no mesosystemic issues were evident and coaches across the board reported positive mesosystems with teachers. The professional literature in Chapter 2 (Costa & Garmston, 2002; Knight, 2007) stressed the importance of building trust between the coach and classroom teacher, and the findings in Chapter 5 supports the idea that positive working relationships can result in more productive coaching. These conversations comprised a very small subset of the data in this study, so it is possible that this finding is not generalizable to all coaching situations. Certainly, Chapter 5 also offered examples where coaches reported positive relationships with teachers but conversations were determined to be less productive. The evidence presented by coaching cycle 1 suggests that carefully crafted coaching moves that are responsive to the remarks of the teacher can lead to productive coaching conversations, and supports the notion that providing coaches with opportunities to learn and practice productive coaching skills matters.

Implications

The findings of this study suggest that mathematics coaches have the potential to influence how teachers attend to a range of mathematical tasks of teaching in ways that can productively influence planning and teaching of mathematics. In particular, there are specific skills coaches can develop in their practice that can positively affect this work with teachers, including:

- Development of effective skills in fostering two-way communication
- Development of teachers' professional vision and noticing around MTT and reform-oriented teaching practices
- Development of the coach's own professional vision and noticing of the teacher as a learner, including setting aside time for coaches to plan and anticipate work with teachers
- Understanding and development of productive patterns of coaching moves and interactions that are responsive to the remarks and ideas of teachers
- Development of a range of follow up coaching moves to increase teacher noticing of and work around MTT and reform-oriented practices

- Understanding as to how the development of these skills can help to decrease the influence of negative contextual factors and increase the influence of positive contextual factors in fostering productive coaching

These findings also suggest that there is more to be learned about how coaches go about trying to help teachers consider a range of these teaching tasks in their planning and lesson reflection and to develop a professional vision centered around attending to MTT. The findings from this study offer possible implications for teachers, coaches, coach professional developers and supervisors, as well as directions for future research.

For Teachers Who Work with Mathematics Coaches

If one of the goals of mathematics coaching is to help teachers learn how to work with coaches in order to increase their attention to mathematical tasks of teaching and increase their implementation of reform oriented teaching practices, then it is important for teachers to develop an understanding as to why this work is important and what the role of the coach is. One factor that led to a decline of productivity was when teachers appeared less aware of the MTT and how particular coaching moves attempted to engage them in discussion and work around these teaching tasks. In these instances, teachers tended to focus on organization and logistical issues instead of the sorts of teaching tasks that could help them develop reform-oriented ways of thinking about and teaching mathematics.

This is in line with what Sherin and van Es (2009) found in their studies on teacher noticing. Developing teacher awareness as to the purpose of coaching conversations, as well as a professional vision that is centered around noticing MTT, could be a critical component in increasing the productivity of coaching moves and minimizing the potential influence of negative contextual factors on coaching sessions. When teachers understand that a central goal of coaching is to help focus planning around MTT and connecting MTT themes, they can become good “consumers of coaching” (Yopp, et al., 2011). This can help teachers and coaches develop the two-way dialogue that is needed for productive coaching to occur. Providing supports to increase teacher knowledge of coaching roles and develop professional vision focused on MTT can help to minimize the potential influence of micro- and mesosystemic factors on coaching conversations and increase the productivity of this work.

For Mathematics Coaches

Understanding what it looks like for coaches to engage in substantive coaching conversations where coaching moves productively shift teacher attention toward a range of MTT and MTT themes was a needed addition to the current body of research on mathematics coaching. It is important that coaches have a sense of how to help teachers incorporate a range of mathematical tasks of teaching (Ball, Thames, & Phelps, 2008) into their planning, and what to do when teachers do not readily attend to these teaching tasks on their own. Often in the existing literature, the sorts of coaching moves described left much to the imagination as to what precisely coaches can do to engage in work with teachers that is consistently productive (Bay-Williams, McGatha, McCord Kobett, & Wray, 2014; Campbell, Ellington, Haver, & Inge, 2013). Coaches need to develop specific skills in order to engage teachers in meaningful two-way dialogue, including the development of a repertoire of MTT specific coaching moves, as well as a range of potential follow up moves. Coaches must also learn how to design coaching interactions in patterns that focus the conversation around meaningful mathematical topics, much in the way that purposeful questioning patterns can. Much like they do with classroom teachers, coaches must also learn to develop their own ability to notice when teacher learners are attending or not to the MTT at the heart of the conversation in productive and unproductive ways.

It is important that mathematics coaches understand how using a range of coaching moves that connect all three MTT themes, and can learn to develop patterns of interactions that are responsive to the remarks and noticing of the classroom teacher. Developing productive patterns of coaching interactions could potentially minimize the influence the sorts of contextual factors that can make it challenging for teachers and coaches to connect around the common goal of noticing MTT. It can also help teachers to develop a professional vision around MTT that transcends work on a single lesson with a coach and becomes a thinking and planning process for teachers over time. In order for coaches to do this well, coaches should consider their own planning and anticipating practices when preparing to have coaching conversations with teachers. The potential to create reform-oriented shifts in teacher practice illustrate the importance of providing adequate supports to mathematics coaches that help them develop these sorts of coaching skills in ways that can meaningfully impact teacher practice.

For Coach Professional Developers and Supervisors

This study offers several insights that could help mathematics coaches better understand how to engage teachers in productive conversations around mathematical tasks of teaching, regardless of the presence of particular contextual factors. Since coaches often cannot remove the contextual factors that are present in their ecological systems with teachers, helping them develop their coaching practice in ways that can minimize the influence of these factors is critical. Training and supports for mathematics coaches must go beyond offering a generic list of good "coaching moves," and should focus instead on developing patterns of coaching interactions that focus teacher talk around MTT and are responsive to the teacher's contributions to the conversation. This includes work with coaches not only around individual coaching moves, but how to sculpt substantive and meaningful conversations with teachers that are focused and help teachers to make connections and generalizations about their teaching practice, much in the way Stein and Smith (2011) articulate is necessary for teachers to do with students when they orchestrate productive discussions. Helping coaches learn how to intentionally plan for this work with teachers is another dimension of coaching support that is worth considering.

The current professional literature on coaching does not adequately address how to help coaches enact productive coaching conversations centered around goals, problem design, and student thinking in ways that are both substantive in nature and responsive to the teacher as both a collaborator and a learner, simultaneously. Future training and ongoing supports for mathematics coaches are needed to help coaches understand what it looks like to do this in practice and within a range of contexts. Providing these types of supports can help mathematics coaches develop their own noticing and professional vision in ways that are responsive to their dialogues with teachers around MTT. If the goal of coaching is to help teachers engage in systematic ways of thinking about planning for mathematics lessons, then training program and support systems for coaches need to help coaches learn how to develop a coaching practice that helps teachers to generalize the dialogue beyond the span of a single lesson.

For Future Research

Examining coaching moves within the three part coaching cycle allowed for a the development of a more complete understanding of what it means for mathematics coaching moves to be productive. In some instances, coaches guided conversations that focused around many layers of reform based teaching practice, including discussion of mathematical goals, designing meaningful problems, and anticipating and analyzing students' mathematical thinking. Productive coaching moves relied not only on the phrasing and patterns of interactions on the part of the coach, but also those of the classroom teacher. This study was designed as foundational research, in order to develop a working theory of what constitutes productive mathematics coaching moves and conversations. Additional research is needed to further test and develop the definitions and theories examined in this study.

Few studies have closely studied what it looks like for coaches to enact the coaching moves the professional literature prescribes as "effective." This study suggests that the research of Sherin and van Es (2009) around helping teachers to develop selective noticing in ways that shifts their professional vision toward attending to mathematical tasks of teaching could be worthwhile to further pursue with regard to studies on mathematics coaching. The enactment of coaching conversations is similar to how teachers attempt to orchestrate productive discussions with students (Smith & Stein, 2011). Having such discussions requires planning on the part of the classroom teacher, and likewise, coaches need time and opportunity to plan for these coaching conversations for classroom teachers to develop purposeful questions and ideas that can move the conversation forward productively. It was beyond the scope of the current study to examine the sorts of preparation coaches did to set goals, anticipate, and prepare to monitor and notice work with their teacher learners during coaching sessions. It would be interesting to examine this factor in future research on productive coaching to better understand how this planning for the coaching cycle influences the productivity of coaching conversations.

It was beyond the data collection and analysis of the current study to understand how all levels of the ecological system may have influenced the productivity of coaching moves and conversations with classroom teachers during the coaching cycle. For example, no evidence was collected of the microsystemic beliefs of the classroom teacher to understand how this may have influenced their interactions with the coach. Although limited data was collected on the beliefs of the coaches at the onset of the study through the initial surveys that were administered, the focus of the analysis shifted in other directions and so this data did not enter into the findings at this time. Additional research on ways in which the microsystemic beliefs of both the teachers and coaches may have influenced the productivity of coaching moves and patterns of interactions could help provide new insights into this ecological level and its interplay with coaching conversations.

There are a range of future studies needed, not only to further inform the findings of this research, but also to better understand aspects related to the work of mathematics coaches the role of “classroom supporter” (Killion, 2008) that were beyond the scope of the current work. There is still much to be learned about the nuances of how coaches enact substantive and meaningful conversations around reform-oriented mathematics teaching practices (NCTM, 2014), as well as how this coaching work does or does not translate to teacher practice and student learning of mathematics over time.

Conclusion

Mathematics coaches offer a potential form of professional development that can help teachers learn to develop reform-oriented practices around planning and teaching mathematics. This study offers insights into what constitutes productive coaching moves and how coaches go about enacting them during planning and debriefing sessions in the three part coaching cycle when the goal is to help teachers learn to attend to MTT in their practice. The findings presented here suggest that to improve the productivity of coaching practice, specific coaching skills need to be developed and sustained, and that a range of stakeholders must be included in this process, not just the coaches themselves. The skillsets of the leaders who train and support coaches, those of the coaches themselves, as well as the classroom teacher, all stand to gain from the findings of this research. This study provides new evidence of what productive mathematics coaching looks like and how to potentially improve the practice of new and practicing coaches.

Additional research is needed to better understand the ways in which the dialogic interactions between coaches and teachers and the presence of contextual factors influence this productivity. More opportunities are needed to develop an understanding of how to support coaches and teachers in shifting teacher practice toward reform based teaching approaches, and shifting coaching practice toward a range of skills and moves that are more effective. Developing coaching practice and skills that stand to positively influence not only the professional vision and practice of teachers, but also that of coaches, is a complex undertaking that requires the understanding and engagement of multiple stakeholders and perspectives. This study is a first step toward creating a clearer picture of what it looks like when coaches attempt to engage in this deeply reflective practice with teachers in order to help develop more effective coaching practice for the future.

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APPENDIX A

Appendix A

Definitions of the 16 Mathematical Tasks of Teaching

Mathematical Teaching Task	Definition/Characteristics of Task
Presenting Mathematical Ideas	Determining task design and set up, and determining, analyzing, or posing problems with the same/different structures (Selling, Garcia, & Ball, 2016)
Responding to students' "why" questions	Teacher directing of explanations that include deductive reasoning about why a procedure works or why something is true or valid in general, giving mathematical meaning to ideas and procedures. Attempting to develop deeper understanding of concepts and processes for students.
Finding an example to make a specific mathematical point	Matching a task/problem to a particular goal of the lesson/skill or matching word problems with a particular structure (Selling, Garcia, & Ball, 2016)
Recognizing what is involved in using a particular representation	Anticipating benefits and drawbacks of using particular models for a given mathematical task. Anticipating how students might attempt to incorporate such models (both correctly and incorrectly) in the lesson. Selecting, creating, evaluation representations for a given operation or mathematical idea/analyzing representations for the same reason (Selling, Garcia, & Ball, 2016)
Linking representations to underlying ideas and to other representations	When teachers make explicit links between symbols, concrete pictures, diagrams, etc. Utilizing multiple models and helping students see connections between models. Connecting mathematical terms and ideas to analogies/metaphors/stories intended to help students understand mathematical concepts. Connecting or matching representations- matching to operations, to other representations, comparing the validity of two representations (Selling, Garcia, & Ball, 2016)
Connecting a topic being taught to topics from prior or future years	Connected to the domain of horizon math- teachers connect what students are learning to prior knowledge, purpose set for how content will help them in the future (Ball, Thames, & Phelps, 2008)
Explaining mathematical goals	Sharing the goals and purpose of teaching tasks and the curriculum with parents.

and purposes to parents

Mathematical Teaching Task	Definition/Characteristics of Task
Appraising and adapting the mathematical content of textbooks	Determining whether the way the textbook presents content adequately meets the learning goal for the lesson
Modifying tasks to be either easier or harder	Determining and adapting cognitive demand of tasks as written, or substituting alternate tasks to raise or lower the demand of a problem for the lesson
Evaluating the plausibility of students/ claims (often quickly)	Interprets student ideas/claims (processing what they are saying and doing and offering appropriate feedback). Teacher uses and attends to student errors. Analyzing structure in student work (Selling, Garcia, & Ball, 2016). Making sense of student work in relation to instructional goals, mathematical structures, and multiple ways of solving (Kim, 2016)
Giving or evaluating mathematical explanations	Teacher directs mathematical descriptions (with or without student help) that provides clear characterizations of the steps of a mathematical process. Teacher directing of explanations that includes attention to meaning (can include justification). Comparing, critiquing, and improving mathematical explanations (Selling, Garcia, & Ball, 2016)
Choosing and developing useable definitions	In planning and during the lesson, developing academic vocabulary and meaningful definitions for students
Using mathematical notation and language and critiquing its use	Explicit talk about the meaning and use of mathematical language (defines terms, shows how to use them, points out specific labels/names, etc.)
Asking productive mathematical questions	Teacher questions that move the mathematics along
Selecting representations for particular purposes	Selecting models and methods designed to elicit certain features of the mathematics. Appraising, choosing, and modifying tasks for a specific learning goal (Kim, 2016)
Inspecting equivalencies	Connecting or matching representations- matching to operations, to other representations, comparing the validity of two representations (Selling, Garcia, & Ball, 2016)

APPENDIX B

Coaching Observation Tool

Physical Environment:

Coach Moves:	**Teacher Response:**	**Purpose/Outcome of Move:**

APPENDIX C

Informal Pre/Post Observation Questions for the Coach

Pre-Coaching

1. How often do you work with this teacher in mathematics? Describe your typical interactions with this teacher.
2. How often does your work with this teacher include the three part coaching cycle? What have been the areas of focus in some of these previous cycles?
3. Describe how your coaching sessions with this teacher typically look. What happens during the pre-conference? During the lesson? During the post-conference?
4. Describe your anticipated focus for this coaching cycle. What are your goals for the pre-conference? How will you know if you meet them?
5. What other information about your work with this classroom teacher would you like me to know?

Post-Coaching

1. Describe how the lesson and post-conference went. What went particularly well? What did you not expect? What areas would you like to focus on in future work with this teacher?
2. How open was the teacher to discussing the lesson? To receiving feedback? To reflecting on their own practice?

3. Describe the mathematics content that was the focus of the lesson. In what ways did you focus on content with the teacher (e.g. increasing the cognitive demand, making mathematical connections, etc.)?
4. Describe the ways in which you focused with the teacher on engagement, problem solving, or inquiry based learning for this lesson.
5. Describe the ways in which you and the teacher focused on math talk or utilizing effective questioning in the lesson.
6. Describe any data that you and the teacher collected during the coaching cycle. In what ways did the data inform your planning, teaching, and reflection?
7. Describe the goals you and the teacher set that were aimed at implementing ideas and addressing issues you discussed in the pre-conference.
8. Describe the ways in which you and the teacher were reflective about teaching practice. About student learning.
9. Describe the overall impact you believe this coaching session had for this classroom teacher.
10. What factors do you see influencing your work with this teacher?
11. Where will you go next in your work with this teacher?

APPENDIX D

Final Interview with Coaches

1. Describe the work that you typically do with classroom teachers at your school. How much time do you generally spend engaged in each of these types of tasks?
2. How often do you participate with teachers in the three part coaching cycle? Describe what this cycle typically looks like in your work here.
    a. What happens during the pre-conference?
    b. What happens during the lesson? What is your role? The role of the teacher?
    c. What happens during the de-brief? How and when does this part of the cycle take place typically?
3. Describe the things that you typically focus on with classroom teachers related to mathematics in the coaching cycle.
4. Describe the things that you typically focus on with classroom teachers related to pedagogy in the coaching cycle.
5. What types of recurring issues or themes do you see in this work with teachers?
6. Describe any potentially positive factors that influence your work with classroom teachers in the coaching cycle.
7. Describe any potential barriers that may influence your work with classroom teachers in the coaching cycle.

APPENDIX E

Final Teacher Interview Protocol

1. How often do you typically work with your coach?

    - In what ways do you interact together?
    - Can you describe a typical coaching interaction with them?
    - When you are planning with your coach, describe what these interactions typically look like?

2. What is the role of the coach during the lesson typically?

3. What happens in a typical debrief session?

    - What types of things do you tend to talk about with the coach?
    - In what ways are these debriefs beneficial or not beneficial to you as a classroom teacher?

4. Can you describe how it is as a new/veteran teacher working with a math coach?

    - What have you found most helpful or beneficial?
    - Are there drawbacks to working with a coach?

5. What are the potential benefits and drawbacks that you see in the frequency of your coaching work with ______?

6. In what ways has your work with a coach helped you to reflect on mathematical content issues?

    - On management issues?
    - On pedagogical issues?

7. What has been the most meaningful interaction with your math coach this year that you can recall? Why does this work stand out to you?

8. Overall, can you describe any benefits you see in collaborating with a math coach? Drawbacks?

9. Is there anything else you can add about your thoughts on having a math coach in your building or collaborating with them?