ABSTRACT

Title of dissertation:	EXAMINING SECONDARY MATHEMATICS TEACHER CANDIDATES' LEARNING AND ENACTMENT OF MATHEMATICS TEACHING PRACTICES: A MULTIPLE CASE STUDY
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This qualitative case study explored three teacher candidates' learning and enactment of discourse-focused mathematics teaching practices. Using audio and video recordings of their teaching practice this study aimed to identify the shifts in the way in which the teacher candidates enacted the following discourse practices: elicited and used evidence of student thinking, posed purposeful questions, and facilitated meaningful mathematical discourse. The teacher candidates' written reflections from their practice-based coursework as well as interviews were examined to see how two mathematics methods courses influenced their learning and enactment of the three discourse focused

mathematics teaching practices. These data sources were also used to identify tensions the teacher candidates encountered.

All three candidates in the study were able to successfully enact and reflect on these discourse-focused mathematics teaching practices at various time points in their preparation programs. Consistency of use and areas of improvement differed, however, depending on various tensions experienced by each candidate. Access to quality curriculum materials as well as time to formulate and enact thoughtful lesson plans that supported classroom discourse were tensions for these teacher candidates.

This study shows that teacher candidates are capable of enacting discourse-focused teaching practices early in their field placements and with the support of practice-based coursework they can analyze and reflect on their practice for improvement. This study also reveals the importance of assisting teacher candidates in accessing rich mathematical tasks and collaborating during lesson planning. More research needs to be explored to identify how specific aspects of the learning cycle impact individual teachers and how this can be used to improve practice-based teacher education courses.

EXAMINING SECONDARY MATHEMATICS TEACHER CANDIDATES'
LEARNING AND ENACTMENT OF MATHEMATICS TEACHING PRACTICES:
A MULTIPLE CASE STUDY

By

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Dedication

This dissertation is dedicated to my former teachers who inspired me to enter such a challenging yet rewarding profession and to my former students who have helped me improve my teaching practice over the last decade.

Acknowledgements

Graduate school has been an endurance test. I want to start by thanking my family and friends who have supported me throughout this journey over the last five years. My husband, Jim, has been tremendously supportive in my endeavor. He has done the majority of the cooking, cleaning, diaper changing, adventure planning and has helped me keep my sanity. I also need to thank Theodore, my four-month old, who had no idea how much of a motivator he has been in this last year. On any given day, I know I am a phone call away from positive encouragement from my mom, Diana, who is one of my biggest supporters in all aspects of my life. The rest of my family and friends have been tremendously supportive and understanding, especially when I fail to return phone calls or show up with my laptop on holiday breaks. I want to acknowledge my nieces—Kyleigh, Emma, and Dani—who constantly remind me of the broadest level of my work—improving K-12 mathematics education.

I would also like to thank the Clarkson family for always checking in on my progress, but never questioning my completion date. I owe a huge thank you to Trent Clarkson for the endless hours of Civilization that he has played with my husband Jim, which has allowed me to finish readings, papers, comps, and this dissertation.

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teacher education and creating supportive writing groups, and Elizabeth Fleming for everything! Elizabeth has been an amazing colleague and friend who has spent endless hours talking about mathematics, teaching, supervising, as well as life issues. Elizabeth's insightful feedback is unmatched and I definitely would not have finished this dissertation without her encouragement.

I am extremely grateful to my dissertation committee members who have been nothing but supportive since the proposal. The committee contains a collective wealth of knowledge regarding research and teacher preparation and most importantly they are outstanding teacher educators and have served as excellent role models as I experiment as a teacher-researcher. Lastly, I must thank Jack, Jill, and Meredith and all of the other participants who volunteered to be part of this study.

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Chapter 1: Introduction

Accepting a more ambitious vision for student learning challenges [teacher educators] to prepare new teachers to do a kind of teaching that most experienced teachers are not yet doing. Because universities are currently thought to be unsuccessful in preparing novices for practice, we are faced with two challenges: preparing beginning teachers to actually be able to do teaching when they get into classrooms, and preparing them to do teaching that is more socially and intellectually ambitious than the current norm. (Lampert, Franke, Kazemi, Ghousseini, Turrou, Beasley, Cunard, & Crowe, 2013, p. 226)

My Story

I believe that teacher preparation programs are essential for the success of the teaching profession. I wholeheartedly agree with the TeachingWorks slogan that "great teachers aren't born; they're taught." I believe there are invaluable skills, resources, knowledge and experiences that only a strong preparation program can provide a future teacher. While many teachers enter the profession feeling unprepared, I was fortunate to have a strong mathematics education foundation. The next section provides an overview of my journey thus far as a mathematics teacher and teacher educator. My goal is to provide the reader with a sense of my experiences and why I feel so strongly about the potential of teacher education programs.

Although I do not come from a family of teachers, I decided early in life that I was going to become one. I enjoyed school and learning and I admired many of my

teachers. Perhaps one of my most influential teachers and role models was my high school mathematics teacher and basketball coach. Following in his footsteps, I enrolled in my hometown university, Western Michigan University (WMU), and declared a major in secondary mathematics education. While I had always been successful with school mathematics, I had no idea what was in store for me—mathematically or pedagogically.

My pure mathematics courses fluctuated between extremes. I had outstanding professors who instilled in me excitement for mathematics. In these courses I explored mathematical topics at my own pace and had professors who supported me in my thinking. On the other hand, I had un-inspirational professors who shunned me for not memorizing proofs and formulas. I also had several positive extra-curricular experiences, like winning the freshman mathematics prize competition; and other situations, like the Putnam exam, where I floundered. While I was successful in all of my education courses, I found them too generic and I could not see the application to teaching mathematics. The same cannot be said for my mathematics education courses or professors—these people and experiences were truly influential in my development as a teacher.

I took three mathematics methods courses while an undergraduate at WMU and I found all three to be transformative. I recall entering my first course with nothing but mathematical confidence. This course introduced me to the National Council of Teachers of Mathematics and their newly released *Principles and Standards for School Mathematics* (2000). This document soon became my bible. I quickly realized that I could not explain the why behind most of the mathematics procedures I was previously so comfortable with (e.g., invert and multiply). While I found this disturbing, it was also motivating. These experiences pushed me to challenge my own mathematical

understandings and to recognize the level of mathematical understanding required to be a teacher of mathematics.

After graduation, I accepted a full-time high school teaching position at my alma mater, Portage Central High School (PCHS). My first year was stressful. While I felt prepared for the mathematics classes I was teaching, I felt extremely unprepared for the two physics courses I was assigned. Physics was my minor and I had taken several content courses, but never any methods courses. Luckily, a veteran physics teacher unofficially mentored me. He let me observe a section of his physics class each day during my planning period and was available each day after school to help me lesson plan. He also invited me to attend a national physics conference, as his co-presenter. While this collaboration helped me feel better prepared for the physics course, it left all of the planning for my mathematics courses for outside the school day.

My second-year teaching schedule consisted of all mathematics courses, but I found myself again with a new preparation. During this year I also began a concurrent two-year master's degree in secondary mathematics education at WMU, so I was extremely busy.

During my six years of teaching at PCHS I taught six different courses. I used three different sets of curriculum materials, none of which provided district-funded professional development. Each time I became comfortable with materials, the district switched to a new curriculum. While these changes required a lot of planning, it allowed me to experience topics being approached from several different angles. I was getting ready to start my seventh year with yet another new preparation, but a change due to a family situation led me to teach at the university level.

I was hired as an assistant professor in the mathematics department at a small liberal arts college in West Virginia. I was assigned to teach college algebra, discrete mathematics, and a trial version of a new secondary mathematics methods course. While I was excited for this new opportunity, it was met with several disappointments. First of all, the mathematics I was teaching at the university was at a lower level than the mathematics I had been teaching at the high school, which was unexpected. Secondly, I was astounded by the inequities in my students' prior opportunities to learn mathematics (e.g., long term substitutes, no calculus offered). Lastly, I was positioned as the expert in mathematics education due to my master's degree, and I was asked to pave the way for the new secondary mathematics education program. The only resources I had were the materials I had saved from my own undergraduate experience, so I reached out to several of my former instructors to ask for their assistance and updated materials. Overall, I found myself overwhelmed, overworked, and I did not feel I had the time or resources I needed. In the meantime I applied and received the Fey-Graeber fellowship at the University of Maryland.

My teacher preparation program, along with my time spent as a classroom teacher, instilled in me the importance of being a lifelong learner. After ten years of teaching, I can truly say that I am still learning and improving my practice. Transitioning from a student, to a teacher, to a teacher-researcher has been an exciting journey. I hope my research in teacher education uncovers ways to improve the process so the next generation of teachers is prepared for the profession.

Current Educational Climate

As the quote that opens this chapter indicates, teacher educators are expected to

prepare teacher candidates for a type of teaching that is not currently prominent in the

U.S. K-12 mathematics classroom. This type of teaching aligns with the Common Core

State Standards for Mathematics (CCSSM), which call for a more "ambitious vision for

student learning" (Lampert et al., 2013, p. 226). The CCSSM are a set of K-12 standards

and practices that address what mathematics students should know and be able to do to

ensure that all students are college and career ready (CCSSM, 2010). The standards are

intended to be rigorous, coherent, and focused, in an attempt to reduce the amount of

material in typical U.S. curricula, which are often labeled as a "mile wide and an inch

deep" (Schmidt, McKnight, & Raizen, 1997, p. 122). Unlike past mathematics reform

efforts, which have made little impact on actual teaching practices (Hiebert, Stigler,

Jacobs, Givvin, Garnier, Smith, et al., 2005; Stigler & Hiebert, 1999), this initiative has a

concurrent push at the state and district levels that is driven by national level assessments

(i.e., Smarter Balanced or PARCC).

As clearly stated in the CCSSM, "these standards do not dictate curriculum or

teaching methods" (2010, p. 5). The standards only provide the key mathematical content

that should be addressed at each grade level. While teaching methods are not dictated by

CCSSM, some scholars believe that the standards may in fact change the United States'

approach to teaching mathematics (Schmidt & Burroughs, 2013). This is, in part, due to

the fact that the CCSSM goes beyond procedural skill and emphasizes developing

mathematical understanding and productive dispositions. These understandings and

dispositions are evident in the Standards for Mathematical Practice, which includes

practices such as *make sense of problems and persevere in solving them*, *reason

abstractly and quantitatively*, and *construct viable arguments and critique the reasoning*

of others (CCSSM, 2010). While the SMP describe what it means to do mathematics, it is up to the teacher to create meaningful experiences for students to develop these practices. The CCSSM do not provide guidance on how to create these experiences. This is unfortunate, because doing mathematics in ways that align with the SMP will "likely be a new, and perhaps, alien experience for many teachers" (CBMS, 2012, p. 11).

More ambitious student learning will require a shift in teaching practices. While some mathematics education programs have encouraged a shift in the way mathematics has been taught for over three decades, these methods were often in conflict with the expectations of teachers once in the classroom (Ball & Cohen, 1999). For example, in the past, a classroom environment that encouraged student-to-student interactions might be mistaken for a chaotic, poorly managed classroom. However, as identified above, the SMP expect students to critique the reasoning of others, thus encouraging student-to-student interactions. This means that teacher educators must adjust the way in which we are preparing future mathematics teachers so that they are capable of establishing and managing classroom environments that support student interactions. Thus, the current K-12 mathematics education climate provides a window of opportunity to prepare future mathematics teachers for more ambitious teaching.

This type of teaching, however, is not unfamiliar to the mathematics education research community and is often referred to as ambitious teaching. "Ambitious teaching requires that teachers teach in response to what students do as they engage in problem solving performances, all while holding students accountable to learning goals that include procedural fluency, strategic competence, adaptive reasoning, and productive dispositions" (Kazemi, Franke & Lampert, 2009, p. 11). Thus, ambitious teaching

practices require a shift from traditional teacher-centered instruction toward more

student-centered instruction, which provides students an opportunity to interact and share

their mathematical thinking. According to Oliveira and Hannula (2008), "teaching

through meaningful interactions with students is one of the most demanding aspects" of

the profession (p. 19). This, perhaps, is one of the reasons why ambitious teaching is not

the current norm in U.S. classrooms.

While ambitious teaching may not be wide spread, teacher educators are

challenged to prepare teacher candidates (TCs) for this type of teaching (Curcio,

Schwartz, & Brow, 1996; Feiman-Nemser, 2001; Lampert et al., 2013). However, Cohen

(2011) acknowledges that ambitious teaching "requires considerable training" (p. 47).

Teacher educators who have taken up this challenge of preparing teachers for more

ambitious teaching are also supporting a push toward practiced-based teacher education

(Forzani, 2014).

Rationale for the Study

In response to the need to prepare future teachers for more ambitious teaching,

teacher educators are attempting to reorganize teacher education around core practices—

or routine practices of the profession (Core Practice Consortium, 2014). Moreover, there

is a call to situate this learning in the practice of teaching, which teacher educators are

referring to as practice-based teacher education (Forzani, 2014). This case study research

aimed to gather a more in-depth understanding of three teacher candidates' learning and

enactment of discourse-focused mathematics teaching practices as they progressed

through a preparation program that emphasizes ambitious mathematics teaching practices

and practice-based course assignments. Moreover, it sought to identify the tensions

encountered as the TCs enacted discourse-focused practices, since ambitious teaching is not the norm in mathematics classrooms in the United States.

In an attempt to build on the current mathematics education research, I chose to study a subset of three of the eight mathematics teaching practices (MTP) identified in *Principles to Actions* (NCTM, 2014):

Facilitate meaningful mathematical discourse

Pose purposeful questions

Elicit and use evidence of student thinking

This particular subset of discourse-focused teaching practices was chosen in response to the current challenge of preparing teacher candidates for more ambitious teaching practices. The exploration of mathematics classroom discourse, and more specifically the teacher's role in facilitating this discourse, is prevalent in the field (Johnson, Steele, Herbel-Eisenmann, Leatham, Peterson, Stockero et al., 2013; see Walshaw & Anthony, 2008 for a review). However, most of this research has focused on in-service teachers. Research on teacher candidates' classroom discourse practices is rare. This is troubling because Lampert and colleagues (2010) identify discourse as one of the most challenging, but crucial, aspects of ambitious teaching for novices to learn. Thus, this research aims to contribute to the field by exploring how teacher candidates' learn and enact these three discourse-focused mathematics teaching practices.

Classroom discourse can easily be captured via audio or video allowing teacher candidates to analyze and reflect on these artifacts of instruction. Thus, practice-based teacher education coursework can support TCs in these analyses and reflections. Research has shown that using artifacts of the teacher candidate's classroom instruction

can help bridge the gap between coursework and field experiences (Ensor, 2001). This dissertation research uses audio and video recordings from the teacher candidates' methods courses and field placements to explore shifts in their discourse practices.

Below I provide the specific research questions that drive this dissertation study and describe the theoretical perspective that this research takes. I conclude this chapter with an overview of the remaining chapters.

Research Questions

Taking a situative perspective and employing a case study methodology, this dissertation aims to address the following research questions:

1. What are the shifts in teacher candidates' discourse practices when enacting mathematics instruction over the course of a 13-month post-baccalaureate program?

2. How do TCs perceive various activities in the methods course influencing their learning and enactment of discourse-focused mathematics teaching practices?

3. What tensions do TCs encounter as they learn and enact discourse-focused mathematics teaching practices?

Theoretical Perspective

The interactional nature of these three discourse focused MTP requires a theoretical perspective that will recognize these interactions as learning opportunities. Thus, this research employs a situative perspective that stems from sociocultural theory. Sociocultural Theory, a psychological theory based on the work of Lev Vygotsky, contains several assumptions about the nature of learning and knowing. Sociocultural

theory incorporates not only the engagement of the learner in an activity, but the situation in which the activity takes place. More specifically, "knowledge is constructed in practical activities of groups of people as they interact with each other and their material environments" (Greeno, Collins & Resnick, 1996, p. 16). The situation in which a person learns is critical to what is learned (Franke & Kazemi, 2001; Peressini, Borko, Romagnano, Knuth, & Willis, 2004), a concept often referred to as a situative perspective.

Taking a situative perspective, learning is defined as a change in participation or practice, and it occurs through the process of enculturation—or legitimate peripheral participation (Brown, Collins, & Duguid, 1989; Greeno, Collins & Resnick, 1996; Lave, 1991). Thus, teacher learning, "is the movement of teachers from peripheral (novice) to full (expert) participation in the specific working practices and their associated ways of knowing and thinking which define particular school circumstances" (Kelly, 2006, p. 507). This transition from novice to expert occurs while the TCs are engaged in the practices of teaching while constantly reflecting (Feiman-Nemser, 2001; Kelly, 2006). The enactment of these teaching practices takes place in a collaborative dynamic context involving students and teachers. The situative perspective "offers a way of disentangling—without isolating—the complex contributions of these various contexts to novice teachers' development" (Borko, Peressini, Romagnano, Knuth, Willis-Yorker, Wooley et al., 2000, p. 196; Peressini, Borko, Romagnano, Knuth, & Willis, 2004, p. 71). In short, the situative perspective allows for the consideration of teacher learning in two contexts—the field placement and methods course.

Significance and Contributions

While research on in-service mathematics teacher learning is abundant (see Goldsmith, Doerr & Lewis, 2014 for a review), research on teacher education is a fairly new field (Grossman & McDonald, 2008). A recent survey showed that the majority of research on mathematics teacher education is small scale, conducted in English speaking countries, and conducted by teacher educators on their students (Adler, Ball, Krainer, Lin, & Novotna, 2005). This survey also highlights gaps in the field. One area that is identified as needing further research is "teachers' learning from experience" and more specifically, "what helps some teachers to develop from their own teaching while others do not" (Adler et al., 2005, p. 376). While this study is small in scale, and conducted by the teacher educator, it aims to address this gap by exploring TCs' learning via practice-based assignments that include examining audio and video recordings of their own practice as they learn to enact discourse-focused practices.

Building on the mathematics teaching practices set forth by the NCTM (2014), this research aims to further understand TCs' actual classroom enactments of discourse-focused mathematics teaching practices and the tensions they encounter. If teacher educators have a better sense of the classroom discourse of TCs and the challenges they face during enactment, then they may be able to better support them. Moreover, understanding how practice-based course assignments developed from a common framework (McDonald, Kazemi, & Kavanagh, 2013) support TCs in their learning and enactment can help advance the field as we try to create a practice-based curriculum of teacher education.

Overview of the Document

Chapter 2 of this document provides the reader with a background of the current practice-based teacher education movement. This chapter further explores the relevant research behind the three discourse-focused mathematics teaching practices that will be examined in this research. I conclude the chapter with a description of the conceptual framework that guided this study.

In Chapter 3, I present the reader with the methods and methodology. I specify the research setting, methodology and participant selection criteria. I also describe the data sources and the course assignments they supported them. Chapter 3 also explains how the data were coded and analyzed for this study.

Chapter 4 provides the reader with an overview of the two mathematics methods courses to help set the context for this study. I describe the types of pedagogies that were used in the method courses drawing from common language in the field (McDonald et al., 2013). Finally, I highlight the activities the teacher candidates experienced on specific days in each of the methods courses during which the three discourse-focused teaching practices were focused.

Chapter 5, 6 and 7 address the first research question and provide the reader an insight into the discourse practices of the three teacher candidates. Chapter 5 depicts Jack's shift toward a facilitator of mathematics discourse. Chapter 6 shows evidence of Jill refining her discourse practices through the use of practice-based assignments. The case of Meredith and the way in which she navigated her mentor's norms as she tries to enact discourse practices is presented in Chapter 7. As these three chapters unfold I compare and contrast the discourse practices of the candidates.

Chapter 8 provides a cross-case analysis. I begin by identifying the discourse practices that were infrequently used or absent across the three cases. Then, I explore the teacher candidates' perceptions of the methods course activities, which addresses the second research question. Finally, I identify the common tensions among the three teacher candidates as they enacted discourse practices in their field placements.

Chapter 9 offers the reader a summary of the dissertation research and a discussion of the difficulties I encountered as I sought to use a common framework and language. I also provide implications that my findings have for teacher education as well as directions for future research.

Chapter 2: Review of Relevant Literature and Conceptual Framework

This chapter provides an introduction to the current climate in teacher preparation, which includes the push for practice-based teacher education and the redesign around core practices. The mathematics education community has identified a set of eight core-practices. I unpack a subset of three of these practices, which are the discourse-focused teaching practices that are explored in this study. I conclude the chapter with the conceptual framework that guided this study.

Practice-Based Teacher Education

Recently, prominent teacher education scholars proposed a redesign for teacher education (Ball & Forzani, 2009; Grossman, Hammerness, & McDonald, 2009; Grossman & McDonald, 2008; Franke, Kazemi, & Battey, 2007; McDonald, Kazemi, & Kavanagh, 2013). This redesign suggests that teacher education be organized around a set of core practices. The main component behind practiced-based teacher education is the notion of learning opportunities that are situated in the work—or practice—of teaching (Forzani, 2014). This may include the study of one's own teaching practices, but it can also be the use of other artifacts of teaching (Ball & Cohen, 1999; Ghousseini & Sleep, 2011). Practice-based teacher preparation, however, is not a new construct.

Practiced-based teacher preparation (PBTP) surfaced in the 70s and was grounded in behavioral psychology (Zeichner, 2012). The PBTP of the 70s consisted of long lists of teacher competencies. PBTP resurfaced during the 80s during the paradigm shift from behavioral to cognitive psychology, when case-based methods became prominent (McDonald et al., 2013). One feature that distinguishes this new movement from previous PBTP is the focus on content specific practices (Ball & Forzani, 2009) and

notions of ambitious teaching (Forzani, 2014). In summary, the goal of the current PBTP movement is to develop teacher candidates' knowledge of teaching practices as well as their ability to enact these practices within specific content areas.

There are a variety of terms being used to discuss the pedagogies of teacher education (e.g., rehearsals, approximations, modeling, micro-teaching, role play, case analysis, simulations, and representations). While many of these pedagogies take place in controlled settings, such as a university methods class, the practice-based movement is looking to blur the line between the university setting and more authentic K-12 school settings (McDonald et al., 2013). As the field progresses in this development, there is a need to develop a common language to describe these pedagogies of teacher education.

This resurgence of PBTE is not without critique. Even proponents of this movement recognize the inherent difficulties of shifting toward pedagogies of enactment (Ball & Forzani, 2009; Grossman & McDonald, 2008). Teacher educators must find ways to decompose teaching practices to make them "studyable", without losing their inherent complexities (Ghousseini & Sleep, 2011). Furthermore, teacher educators need to understand how teacher candidates are recomposing these teaching practices to avoid developing only routine experts (Janssen, Grossman, & Westbroek, 2015). This leads to one of the persistent dilemmas in teacher preparation—transfer. The issue of transferring, or recontextualizing, knowledge and skill from one situation to another (Ensor, 2001; Hiebert & Morris, 2012) will continue to be a challenge because ambitious teaching leads to some unpredictability. Scholars behind the PBTE movement are well aware of these challenges and are seeking to identify specific pedagogies of teacher education that may help teacher candidates learn core practices.

Currently, there are a variety of terms that address similar constructs regarding these practices (e.g., core practices, high-leverage practices, core high-leverage practices, high-leverage instructional practices, and high-impact instructional routines). Core practices, despite no agreed upon definition, typically have the following characteristics: "Practices that occur with high frequency in teaching; Practices that novices can enact in classrooms across different curricula or instructional approaches; Practices that novices can actually begin to master; Practices that allow novices to learn more about students and teaching; and Practices that are research-based and have the potential to improve student achievement" (Grossman et al., 2009, p. 277). In short, core practices can be seen "as building blocks for teaching more ambitiously" (Janssen, Grossman, & Westbroek, 2015, p. 144). Advocates of the current practice-based movement do not aim to create a common list of core practices that would apply to all content areas and all teacher preparation programs (Core Practice Consortium, 2014; McDonald, Kazemi, & Kavanagh, 2013). As mentioned above, scholars have recognized that these core practices will likely differ by content areas (Franke, Kazemi, & Battey, 2007; Forzani, 2014). In the next section, I discuss the most recent list of core practices for mathematics teaching proposed by the National Council of Mathematics Teachers.

Mathematics Teaching Practices

A recent NCTM publication, *Principles to Action*s (2014), provides a list of eight mathematics teaching practices. According to NCTM (2014), these practices "represent a core set of high-leverage practices and essential teaching skills necessary to promote deep learning of mathematics" (p. 9). The eight practices are as follows: establish mathematics goals to focus learning; implement tasks that promote reasoning and problem solving; use

and connect mathematical representations; facilitate meaningful mathematical discourse; pose purposeful questions; build procedural fluency from conceptual understanding; support productive struggle in learning mathematics; and, elicit and use evidence of student thinking.

Many of these constructs are not new, and in fact, have been promoted in other NCTM initiatives; however, previous articulations have not been in terms of teaching practices. For example, the *Professional Standards for Teaching Mathematics* (NCTM, 1991) identified Standard 2 as the Teacher's Role in Discourse. This standard overlaps with many of the practices identified above (e.g., posing questions and tasks that elicit, engage, and challenge each student's thinking). These Teaching Standards were reiterated again in the *Principles and Standards for School Mathematics* (2000); however, the vast majority of U.S. classrooms did not take up these principles (Stigler & Hiebert, 1999). Thus, the clear articulation of these mathematics teaching practices comes at much needed time as the mathematics educational community prepares for the implementation of the more ambitious CCSSM.

This research examines three of the mathematics teaching practices more closely: facilitate meaningful mathematical discourse, pose purposeful questions, and elicit and use evidence of student thinking. These three discourse-focused mathematics teaching practices are interrelated and critical for the ambitious teaching expected by the CCSSM. In order for a teacher to facilitate meaningful discourse, the teacher must pose purposeful questions that allow students to share their thinking. Ambitious teaching strives for these interactions and for student ideas to drive the mathematical conversations. Below I

attempt to separate these three interrelated practices and highlight what we know from the current research and literature.

Facilitate Meaningful Mathematical Discourse

"Discourse is where all cognitive activities start, exist, and come to closure" (Sfard, Nesher, Streefland, Cobb, & Mason, 1998, p. 50). Facilitating meaningful mathematical discourse in the classroom, however, is "an extremely demanding and intricate task" (Sfard, Nesher, Streefland, Cobb, & Mason, 1998, p. 51). In part it is a challenging task because there are embedded issues regarding socialization and what it means to know and do mathematics (Cazden, 2001; Lampert, 1990; O'Connor, 1998; Schoenfeld, 2012; Silver & Smith, 1996).

Discourse is more than discussion; it can include non-verbal forms of communication as well. It is through these forms of discourse that the teacher and students interact with mathematical content. These interactions can support the development of mathematical understanding. In order to develop their understanding, students need opportunities to interact, or to "participate in the discourses of the discipline" (Windschitl, Thompson, Braaten, & Stroupe, 2012, p. 881). In the mathematics classroom, this means students need opportunities to interact, share, discuss and refine their mathematical thinking (Franke, Kazemi & Battey, 2007; Walshaw & Anthony, 2008). However, just constructing an opportunity for interactions does not suffice. Teachers must facilitate these interactions to ensure that the mathematics and connections are highlighted—not lost—in discussion. Facilitating discourse is challenging even for experienced teachers because they have to "navigate the unending string of decision points" (Leinhardt & Steele, 2005, p. 157). Teachers face decision

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points around content issues as well as social issues. As Cohen (2011) acknowledges, the teacher "must manage complicated interactions, keep track of many difficult idea, help regulate students' participation, and help students learn the conventions of the discourse and how to conduct themselves in it, all more or less at once" (p. 156). Thus, the level of unpredictability and the multitude of decision points only add to the challenge of preparing teachers to lead productive discourse.

Discourse patterns. Ambitious teaching practices position the teacher as a facilitator of discourse, who provides students with opportunities to explain their thinking, thus allowing student thinking to drive the conversation. Therefore, a focus on classroom interactions requires a shift away from prevalent discourse patterns. Take for example, the prominent initiation-response-evaluation (IRE) discourse pattern that Stigler and Hiebert (1999) observed in U.S. classrooms. The IRE discourse pattern typically does not require students to share their thinking and allows the teacher to dictate and dominate the conversation. Another common interaction pattern in the United States is referred to as *funneling* (Wood, 1998). This occurs when a teacher asks a series of questions that leads a student toward a particular idea or answer, which may or may not align with the way the student conceives of the problem. An improvement on funneling is what Wood (1998) labels as *focusing*. Focusing is more open-ended and requires that the teacher listen to the student's response and use the student's ideas to guide the discussion.

Transitioning away from traditional teacher dominated discourse patterns toward more ambitious patterns requires changes in teaching practices. Conducting research with in-service elementary teachers, Hufferd-Akles, Fuson, and Sherin (2004) identified four levels in this transition:

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Level 0: traditional teacher-direct classroom with brief answer responses from students;

Level 1: teacher beginning to pursue student mathematical thinking;

Level 2: teacher modeling and helping students build new roles; and

Level 3: teacher as co-teacher and co-learner.

Any change in discourse pattern beyond Level 0 will likely require changes in classroom norms (Silver & Smith, 1996; Yackel & Cobb, 1996).

Sfard, Nesher, Streefland, Cobb, and Mason (1998) note that "the art of communicating has to be taught" and that "communication skills cannot be taken for granted" (p. 51). This means teachers will need to create supportive environments, or discourse communities, that allow for new forms of student interactions (Chapin, O'Connor, Anderson, 2009; Silver & Smith, 1996). For example, teachers need to create classroom discourse norms that hold students accountable for explaining their reasoning, asking questions, and making sense of others solutions (Hufferd-Akles, Fuson, & Sherin, 2004; Michaels, O'Connor, Resnick, 2007; Stephan, 2014). These classroom discourse norms are not directly addressed in the CCSSM; however, they are implied in the Standards for Mathematical Practice. For example, the third SMP states that students should be able to "construct viable arguments and critique the reasoning of others" (CCSS0, 2010). Again, this notion of classroom interaction is not new and can be seen in the Communication Standard (NCTM, 2000), Reasoning and Proof Standard (NCTM, 2000), and Adding it Up (NRC, 2001). While these interactions are not typical in U.S. classrooms, it is clear that the teacher plays a key role in supporting an environment that encourages classroom discourse.

Five practices for orchestrating productive discussions. Recent publications have articulated specific teaching practices and discourse moves to help teachers facilitate meaningful classroom discourse (Chapin, O'Connor, Anderson, 2009; Cirillo, Steele, Otten, Herbel-Eisenmann, McAneny, & Riser, 2014; NCTM, 2014; Smith & Stein, 2011). One prominent publication regarding the teacher's role in classroom discourse is *The Five Practices for Orchestrating Productive Mathematics Discussions* by Smith and Stein (2011). As the title states, this publication identifies five practices for orchestrating productive mathematics discussion, which are as follows:

(1) anticipating likely student responses to challenging mathematical tasks;

(2) monitoring students' actual responses to the tasks (while students work on the tasks in pairs or small groups);

(3) selecting particular students to present their mathematical work during the whole-class discussion;

(4) sequencing the student responses that will be displayed in a specific order; and

(5) connecting different students' responses and connecting the responses to key mathematical ideas. (p. 8)

Again, these constructs are not newly conceived and can be found in earlier documents (see NCTM, 1991); however, these previous documents did not articulate the practices as clearly. Smith and Stein (2011) provide a sequential set of teacher actions that follows the flow of instruction. These practices go beyond in-the-moment classroom interactions, and begin with the teacher preparing and anticipating interactions (i.e., practice #1). While the grain sizes of these five practices are fairly large, researchers have

also identified more specific in-the-moment teacher discourse moves that can be used within the five practices.

Discourse moves. There are many talk moves that are used by teachers to promote classroom discourse. Researchers, however, have emphasized the following five as a starting place:

(1) revoicing;

(2) repeating: asking students to restate someone else's reasoning;

(3) reasoning: asking student to apply their own reasoning to someone else's reasoning;

(4) adding on: prompting students for further participation; and

(5) using wait time. (Chapin, O'Connor, & Anderson, 2009)

Revoicing, as defined by Chapin, O'Connor and Anderson (2009) occurs when the "teacher essentially tries to repeat some or all of what the student has said, and then asks the student to respond and verify whether or not the teacher's revoicing is correct" (p. 14). Researchers have identified over twenty-five different functions for revoicing (see Herbel-Eisenmann, Drake, & Cirillo, 2009). One common uses of this move is to clarify a student statement, because student's thoughts can be jumbled in "exploratory talk", (Cazden, 2001, p. 91). Another use is simply to reiterate, or rebroadcast, a statement that a teacher wants to emphasize to ensure it was heard.

A teacher may ask a different student to either repeat or perhaps rephrase another student's contribution, which is the second talk move. The third talk move, reasoning, can be used to extend student reasoning to a new problem, but is more commonly used to check for agreement or disagreement with a previous student comment. An important

component to this talk move is to ask the student to explain why and to elaborate on their

reason for agreeing or disagreeing. The fourth talk move, referred to as the adding on

move, is posed to the rest of the class to try to increase participation. This move may

draw additional comments, however, it can also include agreement or disagreement with

previous comments in a similar fashion to the move three. The last talk move—wait

time—consists of no verbal comments on the part of the teacher, instead a few moments

of silence so that students can process previous comments and or questions.

Recently, Kazemi and Hintz (2014) suggested two additional talk moves for this

beginning list: turn and talk, and revise your thinking. Turn and talk provides an

opportunity for the teacher to put the whole class discussion on pause while students talk

with a partner near them. The other move that Kazemi and Hintz (2014) suggested would

allow a student who has made a comment or claim to revise their thinking and make that

revision public.

Initially, the majority of the literature regarding these five talk moves primarily

focused on elementary classrooms; however, these moves are currently being promoted

for secondary mathematics teachers (e.g., Smith & Stein, 2011). Building on the

elementary talk moves, several scholars have created a set of professional development

materials entitled Mathematics Discourse in Secondary Classroom (MDISC) that identify

six teacher discourse moves (TDMs) (see Cirillo, Steele, Otten, Herbel-Eisenmann,

McAneny, & Riser, 2014; Herbel-Eisenmann, Steele, & Cirillo, 2013). These TDMs are

very similar in nature to the five talk moves listed above; however, they have clarified

their usage and focused on the use of verbs to emphasize the action of the teacher.

Additionally, the original talk move that prompted further participation was sub-divided

into two teacher discourse moves—inviting student participation and probing student's thinking—thus creating a total of six TDMs.

Piloting these professional development materials with secondary in-service mathematics teachers, researchers have found that teachers' interpretations and implementations of these moves tend to differ from the researchers original conceptions. This has been particularly true with the revoicing discourse move. Researchers have identified a variety of forms and functions of revoicing (Herbel-Eisenmann, Drake, & Cirillo, 2009) which lead to different interpretations. For example, a teacher may use revoicing as a way to offer more precise mathematical language, to summarize a mathematical idea, or to emphasize the importance of an idea. One teacher who participated in the MDISC professional development defined revoicing much more liberally: "any form of restating an idea presented by another" (Krusi, 2009, p.118). Due to the way the term has been taken up by in-service teachers many teacher educators are using the following definition: "the reuttering of another person's speech through repetition, expansion, rephrasing, and reporting" (Forman, Larreamendy-Joerns, Stein, & Brown, 1998, p. 531). This definition does not include the second part of the revoicing move that O'Connor (2009) claims was not made explicit in early publications—the teacher "asks the student to respond and verify whether or not the teacher's revoicing is correct" (Chapin, O'Connor, & Anderson, 2009, p. 14). For this reason, Herbel-Eisenmann, Steele, and Cirillo (2013), have created the labels of "revoicing", and "full revoicing", where the latter attends to the original definition used by Chapin, O'Connor and Anderson (2013). These labels will resurface in Chapter 3 when I discuss the way I coded specific discourse moves.

Pose Purposeful Questions

Teachers should pose purposeful questions that aim not only to assess, but also to advance students' thinking (Cazden, 2001; NCTM, 2014). In order to advance students' thinking, teachers must first understand the ways in which students are reasoning. This means that teachers need to use classroom questioning as a way to understand student thinking (Driscoll, 1999). If teachers use questions to unpack student thinking, then they will be more prepared to build on and connect mathematical ideas and various student strategies. In short, teachers' questions "shape the mathematical landscape in significant ways" (Boaler & Brodie, 2004, p. 781).

There are several different question type frameworks. For example, Driscoll (1999) highlights five: managing, clarifying, orienting, prompting mathematical reflection, and eliciting algebraic thinking. *Principles to Action* (2014) contains a framework with four question type: gathering information, probing thinking, making the mathematics visible, and encouraging reflection and justification. In an exploration of secondary mathematics classroom lessons, Boaler and Brodie (2004) identify nine different types of questions: gathering information, inserting terminology, exploring mathematical meanings and/or relationships, probing, generating discussion, linking and applying, extending thinking, orienting and focusing, and establishing context.

Teachers commonly use gathering information questions, which ask students to recall facts, definitions or procedures. In fact, all of the teachers in Boaler and Brodie's (2004) study relied heavily on this question type, with two of the teachers showing essentially no variation beyond this type of question. It is important to note that teachers should strive for a variety of question types—those that gather information as well as

those that reveal student thinking (NCTM, 2014). In fact, Franke and colleagues (2009) note "Finding the balance in the types of questions and when to ask them can make a large difference in how students continue to participate" (p. 381).

Research suggests that teacher preparation programs should introduce various types of questioning and support TCs in analyzing their discourse patterns (Blanton, Berenson, & Norwood, 2001; Moyer & Milewicz, 2002). Smith and Stein (2011) suggest that teachers trying to improve their questioning strategies and move beyond low-level questions should focus on incorporating question Type 3, 4, and 5 as identified in Boaler and Brodie's study (i.e., exploring mathematical meanings and/or relationships, probing, generating discussion). These three question types provide students the opportunity to explain their reasoning.

The notion of focusing teacher candidates' attention on questioning practices is not new and can be found in the competency-based teacher education of the 70s; however, the difference in the current core-practice movement is the focus on student thinking (Forazni, 2014). Questions are used to elicit student thinking, thus teachers must listen to (Empson & Jacobs, 2008) and hear (Wallach & Even, 2005) what their students are saying, which are not trivial skills. When teachers listen to their students' thinking, they too become learners (Choppin, 2014; Cohen, 2011; Franke & Kazemi, 2001; van Es & Sherin, 2010). Listening and hearing what students are saying is what allows teachers to build on students' mathematical ideas and to make connections between students' ideas, which brings us to the third mathematical teaching practice.

Elicit and Use Evidence of Student Thinking

Altering teaching practices to incorporate discourse that not only allows for student contributions, but also supports and adjusts lessons to build on these student ideas, is challenging for novices (e.g., Blanton, Berenson, & Norwood, 2001) as well as experienced teachers (e.g., Herbel-Eisenmann, Steele, & Cirillo, 2013; Hufferd-Akles, Fuson, Sherin, 2004). Building on and using student thinking may happen in the moment and change the direction of the discussion, or it may influence subsequent lesson plans. For either event, however, the crucial component is what the teacher is *noticing* (Sherin & van Es, 2003; van Es & Sherin, 2002). Noticing requires the teacher to identify a learning opportunity in a particular situation, to make connections to the practices of teaching and learning, and to use prior content and pedagogical knowledge to reason about the situation (van Es & Sherin, 2002). If the teacher does not notice relevant mathematics in a particular student comment, then there will be a missed opportunity for learning (Leatham, Peterson, Stockero, & Van Zoest, 2015). Thus, teachers are not only expected to notice learning opportunities, they also need to build on and extend the student's thinking in these situations. Building on and extending student thinking requires not only an understanding of the way students think, but a deep understanding of the content itself (Franke & Kazemi, 2001).

Research regarding in-service elementary teachers showed that teachers who elicited student thinking responded to students in varied ways, such as posing additional questions: general questions, clarifying questions, or leading questions (Franke, Webb, Chan, Ing, Freund, & Battey, 2009). Furthermore, researchers have found that teachers who received professional development that focused on exploring student thinking,

whether via video clubs (van Es & Sherin, 2010) or other forms of professional

development (e.g., CGI; Franke & Kazemi, 2001), showed change in their instructional

discourse patterns, specifically in the ways in which they elicited and focused on student

thinking. Researchers in various content disciplines have focused specifically on novice

or preservice teachers and their ability to elicit and respond to student thinking (e.g.,

Levin, Hammer, & Coffey, 2009; Stockero & Van Zoest, 2012; Walkoe, 2015;

Windschitl, Thompson, & Braaten, 2011).

Several researchers have worked with preservice secondary mathematics teachers

in video clubs and found changes in both what teachers noticed and how they interpreted

situations via video (Sherin & van Es, 2005; Walkoe, 2015). However, this line of

research with preservice teachers did not explore the teachers' practices in the classroom.

Researchers are exploring how practice-based teacher preparation assignments might

help TCs in learning and enacting this challenging teaching practice (Sleep & Boerst,

2012). Initial studies that focus on preservice teachers enactment confirm, "teaching that

is responsive to student thinking in any context is complex" (Ghousseini, 2015, p. 353).

Conceptual Framework

This research focuses on the three discourse-focused mathematics teaching

practices elaborated above: facilitate meaningful mathematical discourse, pose purposeful

questions, and elicit and using evidence of student thinking. While NCTM (2014) does

not address the grain size or the relationship between these practices, I interpreted these

three discourse related practices as subsets of one another for this research (see Figure 1

below).
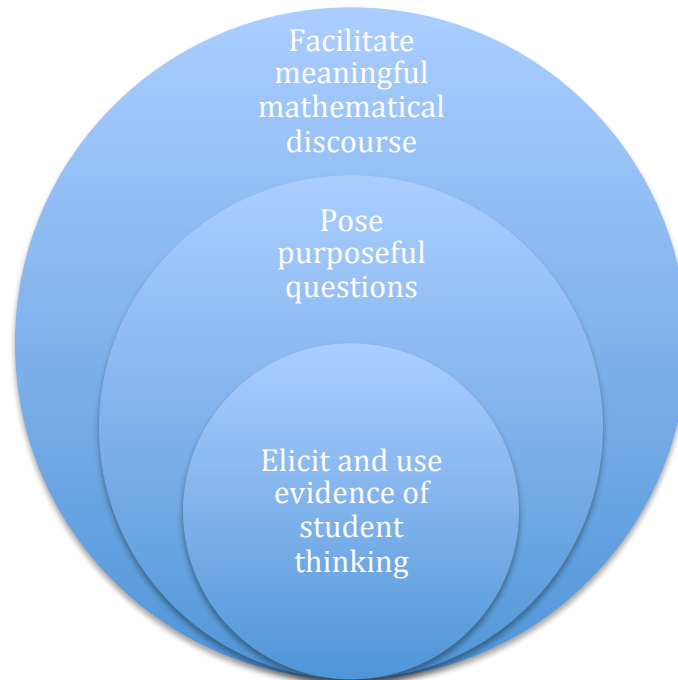
Figure 1. Nested Relationship Between Three Discourse-focused MTP

These three discourse-focused practices were supported throughout the two methods courses in this study. Each of the methods courses and the associated assignments were designed to support teacher candidates in their enactment and reflection on these practices, which will be described in more detail in the next chapter. First, I outline the relationship between these discourse practices and the cycle of learning and enactment and the larger vision of the methods course.

The research questions driving this study focus on teacher candidates' learning and enactment of three discourse-focused mathematics teaching practices, thus a framework that combines the teaching practices with a cycle of learning seems fitting. Below I explain the learning cycle introduced by McDonald, Kazemi, and Kavanagh (2013). Then, I will explain how I adapted this cycle by combining it with the nested

mathematics teaching practices described above. Lastly, I will explain how my adaption differs from the work of McDonald et al. (2013).

Cycle for Learning to Enact Core Practices

The Cycle for Learning to Enact Core Practices, shown in Figure 2, was created by McDonald, Kazemi, and Kavanagh (2013) to serve as a framework for the structure of teacher preparation programs. The learning cycle has four quadrants depicting various pedagogies of teacher education centered on core practices. As the framework is a cycle there is no beginning or end. The notion is to use various pedagogies within preparation programs to help teacher candidates learn to enact core practices. Building from previous teacher education literature, the top right quadrant would be referred to as *representations of practice*. "Representations of practice comprise the different ways that practice is presented in professional education and what these various representations make visible to novices" (Grossman, Compton, et al., 2009, p. 2058). This includes pedagogies common to teacher preparation such as: modeling, examining video exemplars, and using case studies. The bottom right corner aligns with Grossman, Compton, et al.'s (2009) notion of an *approximation of practice*.

"Approximations of practice refer to opportunities for novices to engage in practices that are more or less proximal to the practices of a profession" (Grossman, Compton, et al., 2009, p. 2058). This includes pedagogies that vary in authenticity, such as role playing or teaching ones peers. Essentially, candidates are provided an opportunity to practice in a controlled—or sheltered—environment that has reduced the complexity of teaching.

- **PEDAGOGIES**
- Video Analysis
- Transcript Analysis
- Reflection Writing

- **PEDAGOGIES**
- Modeling
- Examining Video Exemplars
- Examining Written Cases

Analyzing Enactment and Moving Forward

Introducing and Learning About the Activity

- Core Practice
- Core Practice
- Core Practice
- Core Practice

Enacting the Activity with Students

Preparing for and Rehearsing the Activity

- **PEDAGOGIES**
- Co-Teaching
- Live Coaching

- **PEDAGOGIES**
- Collaborative Planning
- Microteaching
- Rehearsal

Figure 2. Cycle for Learning Core Practices (McDonald et al., 2013, p. 382)

The bottom left part of the diagram represents a live *enactment* (Grossman, Hammerness & McDonald, 2009), which may include co-teaching. The top left of the cycle represents what Grossman, Hammerness, and McDonald (2009) refer to as an *investigation of practice*. This part of the cycle allows teacher candidates to reflect on teaching practices. This may include a video or audio analysis of their own teaching, but it can also include a video or transcript analysis of another teachers' practice.

McDonald and colleagues envision this cycle being used with specific activities—or instructional activities. Instructional activities (IA) are seen as "containers that offer novices an opportunity to try on core practices without having to create that opportunity themselves" (McDonald, Kazemi, and Kavanagh, 2013, p. 382). The notion is that

teacher educators have to create experiences that will "prepare [novices] to teach within the continuity of the challenging moment-by-moment interactions with students and content over time" (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010, p. 132). Examples of IA in the mathematics education literature include: choral counting, strategy sharing, strings, and solving word problems (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010). One of the more frequently cited IA is choral counting. This activity has teachers lead and record elementary students counting by various constants (e.g., 2's, 10's) to help develop computational strategies. While some of these IA at the elementary level are well developed and field tested, the same is not true for IA at the secondary level. Teacher educators at this level are just beginning to join forces to explore what this might look like in secondary mathematics. For example, Elliott, Aaron, and Maluangnont (2015) recently identified *going over a problem* in the context of equivalent ratios as an IA they are currently using in secondary teacher education.

One issue is the size of the "container" or activity. Lampert (2012) acknowledges that an instructional activity may include an even larger grain size, such as an entire lesson. Using the lesson as the container aligns with principals of lesson study (Hiebert & Morris, 2012). Some IA are much narrower and content specific, such as equivalent ratios or completing the square. There are clearly some growing pains as the field continues to develop a common language and structure around IA.

Discourse-focused Mathematics Teaching Practices and the Learning Cycle

For this research, I have adapted the McDonald et al. (2013) learning cycle to focus on the three discourse-focused mathematics teaching practices I identified at the beginning of the chapter: facilitate meaningful mathematical discourse, pose purposeful

questions, and elicit and using evidence of student thinking. I have established these as the core practices at the heart of the learning cycle, which is displayed in the figure below.
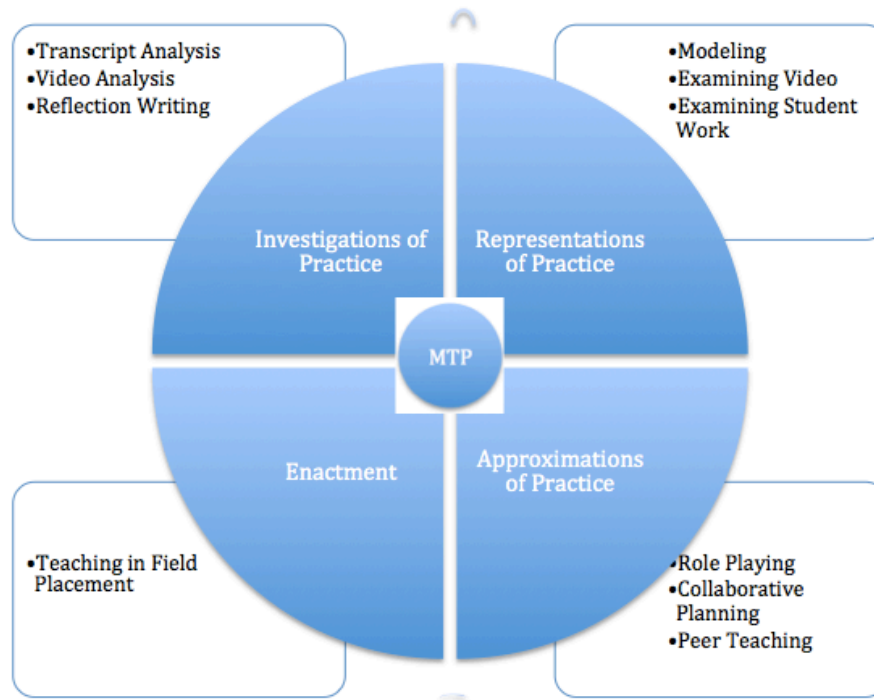
Figure 3. Adapted Cycle for Learning

In this study, the activities in the methods course are viewed as context and the focus is on novice teacher learning in and from these experiences. Chapter 4 presents the reader with an overview of the methods courses and how the phases of the learning cycle were incorporated.

Chapter 3: Research Design and Methodology

This chapter lays out the design of the study. I begin by describing my role in this research, then I describe the design setting, the participants, and the methodology that will be used. I describe the various data sources—audio recordings, video recordings, written analyses, course reflections, and interview transcripts. Then, I explain the data analysis procedures I used. I conclude this chapter by addressing issues of validity and reliability.

My Role

Before describing the design of the study, I should acknowledge my role in this study as a teacher-researcher. I was the instructor for both of the methods courses that will be described in the next chapter. I also was a university supervisor for several of the candidates in the program, which impacted my case selection. The case selection process will be addressed in a subsequent section. The study participants were not chosen until all course grades were submitted, per IRB agreement, and I no longer had an evaluative role for the participants.

Research Setting

This research took place at a large mid-Atlantic public university that has several teacher preparation pathways. Teacher candidates from two of the post-baccalaureate secondary mathematics education programs were in the selection pool for this research. Many of the teacher candidates in these programs are career-changers. This means several years, and in some cases decades, have passed since their last mathematics course. Depending on the candidate's previous career, there was great variability in the level of mathematics courses they have experienced (e.g., abstract algebra vs. calculus I).

A typical post-baccalaureate secondary education mathematics cohort has about 15-20 teacher candidates per year. Roughly 1/3 (approximately 6) of these candidates are enrolled in a federally funded, post-baccalaureate alternative certification. I will refer to this program as ALT throughout this dissertation. The remaining 2/3 (approximately 12) are enrolled in a master's certification program, which I will refer to as the MA program. Although the ALT and MA pathways differ significantly, which will be described below, candidates from both programs combine for the Methods I and Methods II courses.

ALT Pathway

The ALT program consists of a paid, yearlong, part-time, lead teaching position in a local middle school. Candidates in this program are seeking a middle school teaching certificate. During the 2014-15 school year, this program had seven secondary mathematics candidates. These candidates began their program in Summer 2014, taking a middle school mathematics methods course, which will be referred to as the Methods I. When the school year began they were all placed at Hillside Middle School and were considered the teacher-of-record for half of the school day. The ALT program typically pairs two of these candidates together to share a classroom and split the workload of one teacher. These teacher candidates also participated in the Methods II course. During the spring semester each TC in the program was expected to submit a performance-based assessment.

MA Pathway

The MA pathway is a 13-month program that includes a yearlong unpaid internship. Candidates in this pathway are seeking a middle school certification as well as a master's degree. The TCs begin the program taking four courses during the summer,

one of which is a middle school mathematics methods course. When the K-12 public school year begins all of the teacher candidates start a year-long, unpaid, internship. These internships, or field placements, are located within professional development schools (PDS) across several districts. Each candidate is paired with an experienced mentor teacher.

The TCs take two courses each semester during the Fall and Spring. One of these courses each semester is a secondary mathematics methods course; the others are focused on reading and diversity. All candidates are expected to complete a performance-based assessment during the spring semester in addition to their coursework. The MA candidates are also involved in an individual action research project that spans their internship placement. The preparation program culminates with one capstone course during the summer.

Methodology

The phenomenon of interest in this study was teacher candidates' learning and enactment of three mathematics teaching practices. Through examining the audio and video artifacts of the teacher candidates' enactments, I aimed to identify the shifts in their discourse practices. Using their course reflections and interviews I aimed to better understand *how* the teacher candidates negotiate the tensions they encounter when trying to enact these practices; therefore, a qualitative analysis seems fitting (Maxwell, 2013).

This study used a qualitative multiple-case study, which aimed to provide an "in-depth description and analysis of a bounded system" (Merriam, 2009, p. 40). The bounded system, or context, was the teacher candidates' experiences in the teacher preparation program. These experiences included both the candidates' field teaching

experiences as well as the experience in the mathematics methods courses. The ultimate goal of the study was to understand the tensions that teacher candidates faced as they learned and enacted more ambitious mathematics teaching practices. Having more of a nuanced understanding of the constraints TCs faced in the various contexts will allow teacher educators to better support teacher candidates in their development of ambitious mathematics teaching practices. Below I explain how I selected my case study participants for this study.

Case Selection

My agreement with IRB specified that I would not know who was going to participate in this study until the course grades for Methods II were submitted. I saw no benefit in asking for consent at the beginning of Methods II, so I decided to wait until the second to last class session to acquire consent (i.e., December 1, 2014). I wanted the candidates to recognize my passion for teaching and teacher education prior to asking for consent. I hoped this delay would provide me with time to build relationships and, more specifically, trust with the teacher candidates. As novice teachers, I did not want them to feel threatened by my research on their teaching practice.

The IRB consent form (see Appendix A) asked participants to allow me to access and use all of their course assignments and communications for Methods I and Methods II as well as their final program required performance-based assessment. While these artifacts did not require any extra work on the part of the teacher candidates, I also asked for volunteers who would participate in two 30-minute interviews during the spring of 2015. I was unsure of the number of teacher candidates who would consent to the case study during initial planning, so I left my final case study selection criteria undetermined

until I knew the size and composition of the pool of candidates. Below I describe how I conducted the first and second rounds of elimination to identify the potential case study participants.

Round one selection. There were 16 teacher candidates in the Methods II, and 13 candidates signed the IRB consent form. Due to the large number of consenting participants, I developed specific selection criteria to identify three to five participants for the case study. For the first round of selection, I considered two factors: whether the TC had taken both Methods I and Methods II, and if I had any other evaluative role (i.e., university supervisor or instructor) for the remainder of the program. Four of the consenting 13 candidates were not enrolled in the Methods I course due to various reasons (e.g., prior coursework), so I eliminated them from the participant pool since they would not have a complete dataset for the study. I also served as an instructor of a subsequent course and a university supervisor for several of the potential candidates. I felt these evaluative roles might create a conflict of interest during the spring interviews so I did not consider them in the pool of candidates. These two criteria narrowed the pool of 16 candidates down to eight. See Appendix B for a table listing each of the candidates and how these three criteria impacted their involvement in the study.

Round two selection. Two of the eight participants struggled to complete the Methods II coursework and were falling behind in program requirements. In the middle of the semester I expressed my concerns to both participants about their progress. At this point, both candidates had missing assignments and both admitted to being behind on the course readings. While one of these participants had submitted a final classroom video that contained excellent classroom discourse, his course submission dates did not align

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with his peers and did not provide snapshots of his teaching over the course of the program, which is what this research required. After expressing my concerns to the other participant, I initiated an intervention meeting with several program coordinators, which upset the participant. This candidate was extremely overwhelmed and stressed by the situation and I did not want to cause any more distress with participation in this study. Although both of these teacher candidates consented, I decided to eliminate them from the pool.

Two of the remaining six participants had expressed concerns, both written and verbal, about their performance in their field placements. Both were extremely intelligent and thoughtful candidates, who made wonderful contributions during both methods courses; however, each faced challenging placements, which directly impacted the classroom discourse. One candidate was overwhelmed in an under-resourced ESOL classroom, while the other candidate was learning to navigate the U.S. education system and was experiencing self diagnosed culture shock. Although both of these candidates provided consent, they were eliminated from the selection pool.

Study Participants

Data were collected, transcribed, and analyzed for the four remaining participants: Jack, Jill, Jennifer and Meredith. All four participants were placed in middle schools in the same large suburban district; however, they were not all enrolled in the same university preparation program. One of the candidates, Meredith, was enrolled in the MA program, which placed her with an experienced mentor for the year. The remaining three participants were enrolled in the ALT program that listed them as the teacher-of-record

for half of the school day. The ALT participants were all placed as a cohort at Hillside Middle School; however, their unique classroom pairings made them all interesting cases.

I interviewed all four candidates and transcribed all of their audio and video assignments. However, Jennifer failed to submit the final performance-based assessment, so I did not continue to work with her data. Ultimately, this case study research had three participants (see Table 1). Jack and Jill were placed at Hillside Middle School, which was a majority Hispanic (67%) Title I school with 78% of the students eligible for free lunch. Meredith was placed at Meade Middle School, which was majority African American (61%) with 24% of the students eligible for free lunch.

Table 1
Case Study Participants

Teacher Candidate	Program	Field Placement	Grade Level
#1- Meredith	MA	Meade	8th Grade
#2-Jill	ALT	Hillside	7th Grade
#4-Jack	ALT	Hillside	8th Grade

It should be noted that I was closely examining the classroom discourse of novice teachers. This research is not meant to point out any shortcomings, but rather to attend to details that may inform the practice-based teacher education literature. All three of these candidates performed well in the methods courses and completed their programs successfully. I would happily recommend each of the candidates.

Data Sources and Collection

The data sources for this research include four types of data: audio and video recordings, written analyses, course reflections, and interviews. Table 2, shown below, links the various data sources to the three research questions that shaped this study.

Table 2

Alignment between Research Questions and Data Sources

Research Question	Data Sources
What are the shifts in teacher candidates' discourse patterns when enacting mathematics instruction over the course of a 13-month post-baccalaureate program?	3 Transcripts of Audio Recordings 3 Transcripts of Video Recordings 6 Written Analyses
What tensions do TCs encounter as they learn and enact discourse-focused mathematics teaching practices?	6 Written Analyses 2 Course Reflections 2 Interviews
How do TCs perceive various activities in the methods course influencing their learning and enactment of discourse-focused mathematics teaching practices?	2 Course Reflections 2 Interviews

Three of the audio recordings and two of the video recordings were part of the practice-based coursework associated with the methods courses. Five of the corresponding written analyses were also submitted as coursework. Also, each of the methods course had an end-of-course written reflection. The last video and written analysis were submitted to the program as a final performance-based assessment. Lastly, there were two one-on-one interviews that I conducted during the spring semester. Each of these data sources will be described more thoroughly below. Table 3 provides the reader a chronological listing of each of the data sources and the context in which they were recorded or submitted.

Table 3
Summary of Data Sources

Date Recorded/ Submitted	Data Source	Context
mid-June 2014	Audio 1	Methods I
mid-June 2014	Written Analysis 1	Methods I
Late June 2014	Video 1	Methods I
Late June 2014	Written Analysis 2	Methods I
Late June 2014	Methods I Reflection	Methods I
September 2014	Audio 2	Field placement
September 2014	Written Analysis 3	Methods II
November 2014	Audio 3	Field Placement
November 2014	Written Analysis 4	Methods II
December 2014	Video 2	Field Placement
December 2014	Written Analysis 5	Methods II
December 2014	Methods II Reflection	Methods II
February 2015	Video 3	Field Placement
March 2015	Written Analysis 6	Program-level Performance-based assessment

Recordings and Written Analyses

Teacher educators have found video recording to "be an invaluable tool for reinforcing teacher candidate learning" (McDonald et al., 2014, p. 509). The teacher candidates were asked to record their teaching practice six times for this research. There were three audio recordings and two video recordings that spanned Methods I and Methods II. All of the audio and videos recordings had corresponding written analyses that were submitted as coursework.

The first audio recording was approximately 5 minutes in length, the second was 8-10 minutes, and the third was an entire class period, or roughly 40-55 minutes. The first video was approximately 30 minutes in length, the second video was 10-15 minutes, and the last video was 15-20 minutes. Thus, there was approximately one hour of audio

recordings and approximately one hour of video recordings for each of the teacher candidates. Below I further describe each of the recordings in chronological order.

First audio recording and analysis. The first audio analysis took place during Methods I and captured a role-playing activity with a peer. During Methods I, all TCs were presented with a mathematical task dealing with the addition of fractions with unlike denominators. The class was then split into two groups and put in separate classrooms. Each group was given a sample of student work and asked to familiarize themselves with the work so they could role-play. Both groups were told that the student work did not contain any "mistakes", but that the student had a misconception, or wrong idea, regarding some part of the task. For example, one student misconception equated ¼ of an hour to 25 minutes. Once both groups felt comfortable with their roles, the TCs were paired with a peer from the other group. The TCs were then asked to audio record the conversation they had with their peer who was playing the role of a student. The TCs were challenged to apply productive questioning practices to make sense of the student's work and their thinking. They were told that the goal of the activity was to create an opportunity for them to think on their feet and respond to student work in-the-moment.

The written component of the assignment asked the TC to do the following: explain (in your own words) the student's thinking or wrong idea; identify the questions that you posed; explain what your goal was for each question that you asked, and reflect back on your questions and articulate what you learned from examining your question and suggest refined questions (see Appendix C for the actual assignment).

First video recording and analysis. The first video recording was conducted during the last week of Methods I. The TCs were asked to create and teach a 30-minute

lesson to their peers. TCs were provided a practitioner article with a lesson idea from which they were expected to create a lesson plan. Within this lesson plan, TCs were expected to provide anticipated student solutions and potential questions to pose.

After teaching the lesson, the TCs were asked to review their video recording and to address the following prompts that relate to classroom discourse: explain how you monitored, selected, and sequenced student work for productive classroom discourse; explain how you elicited students' mathematical thinking to help develop understanding of the lesson objectives (see Appendix D for actual assignment).

Second audio recording and analysis. The second audio analysis took place during Methods II. Following the first class meeting, the teacher candidates were asked to audio record an 8-10 minute segment, during which they were working with students in their field placement. Depending on the role that was negotiated by the TC and their mentor, this may be a group tutoring session, the TC leading a whole class warm-up, or a portion of a whole class lesson that the TC is facilitating. The TCs were able to choose what segment to record and submit.

Then, the TCs were asked to listen to, transcribe, and analyze their questioning. One of the goals of the first recording was to assess the TCs' retention from the summer methods course (e.g., funneling and focusing questions); therefore, TCs were not given any other formal instruction regarding questioning strategies or teacher moves (see Appendix E for assignment).

Third audio recording and analysis. The third audio recording took place seven weeks later, roughly eight weeks into the Methods II. For this audio, the TCs were asked to record an entire lesson. During the weeks between audio recordings, teacher candidates

were provided readings about classroom discourse (e.g., Arbaugh, 2010; Arbaugh & Avery, 2009; Breyfogle & Herbel-Eisenmann, 2004; Smith & Stein, 2011; Stein, 2007) as well as question types and discourse moves (e.g., Smith & Stein, 2011).

For the third analysis the TCs were asked to try to incorporate some of the new question types and discourse moves discussed in class, such as wait time and revoicing. The TCs were informed that they were not graded on their ability to enact these practices; the expectation of this assignment was for the TCs to practice new discourse techniques and to reflect on their enactment (see Appendix F for assignment). The idea from this assignment stems from a "try this" activity mentioned in Smith and Stein (2011, p. 74).

Second video recording and analysis. The second video recording was completed toward the end of the Methods II (roughly 10 weeks into the 14 week course) and was performance-based. The TCs were asked to select a 10-15 minute video segment of their teaching and respond to several reflective prompts (See Appendix G for assignment). One of these prompts, taken from the edTPA, specifically addresses how the TCs elicited student thinking: "Explain how you elicited and built on student responses to promote thinking and develop conceptual understanding, procedural fluency, **and** mathematical reasoning and/or problem solving skills" (SCALE, 2013, p. 21, emphasis in the original.

Third video recording and anlaysis. The third video recording took place during the spring semester as a part of program completion requirements. All TCs were expected to complete the edTPA practice-based assessment. The edTPA required the submission of a set of consecutive lesson plans, as well as a 15-20 minute video recording. The TCs were also expected to write several commentaries reflecting on their materials. The

program assessed the candidates using fifteen rubrics. The project IRB allowed access to all materials submitted for this performance-based assessment.

Course Reflections

Each teacher candidate was asked to write a course reflection at the completion of Methods I and Methods II. These were personal reflections and thus the assignment was scored on whether it was submitted, not on the content of the reflection. The candidates were asked to submit a 3-5 page double spaced paper. In this paper they were asked to identify their big takeaways from the course as well their strengths and strategies for capitalizing on them, and areas where they wanted to focus their attention. The instructor provided candidates with a list of all of the session foci and the candidates were able to discuss whatever they wished.

Interviews

Each of the three teacher candidates participated in two 30-minute semi-structured one-on-one interviews (Bogdan & Biklen, 2007), which were audio recorded. Both of these interviews were conducted after final grades had been submitted and I no longer served in any evaluative role for the teacher candidates. I explained to the teacher candidates that their honest responses would help improve the program and would not be taken personally.

The first interview took place during February. I began by broadly asking the TCs how they thought the two mathematics methods courses supported them in their learning. Then, I asked more specifically about their progress using questioning practices and discourse moves to elicit student thinking and how they thought the major course assignments and readings impacted their development (see Appendix H for sample

prompts). The data analysis completed prior to the first interview informed specific questions for each candidate. For example, when a TC noted a particular reading was helpful in their annotated bibliographies I inquired about how it was helpful during the interview. Similarly, if certain things were noted on the audio or video recordings in regards to classroom discourse, such as specific student language (e.g., "I agree with Student X because…"), I used this interview to inquire about them. In other words, I used the interview as a tool to confirm and or disconfirm early hypotheses.

The second interview took place in May after the TCs had submitted their performance-based materials to the program. In the second interview, I began by asking how the performance-based assessment went and if they thought they had selected a video clip that highlighted them eliciting student thinking. Then, I again asked them to reflect back on Methods I and Methods II to identify anything that they felt supported or prohibited their work toward improving their questioning strategies and discourse moves to elicit student thinking. Each candidate was then asked what they thought their strengths were when it came to classroom discourse and what areas they were still focusing on improving. To conclude the interview, each candidate was provided three continuums and asked to identify where their current practice was compared to their ideal classroom (see Appendix I for sample interview prompts). These continuums were created from a larger framework developed by Hufferd-Ackles, Fusion, and Sherin (2015). The framework identifies four levels of math-talk learning; however, I did not want the TCs to rate themselves numerically, so I eliminated the scale and in place created a continuum using the highest and lowest levels as extreme values.

Data Analysis Procedures

Data analysis occurred throughout the course of the 13-month program. Since I was the instructor for the math methods courses, I read each of the course reflections and written analyses, listened to each of the audio recordings, and watched all of the video recordings. However, since I was unable to identify the case study participants prior to the submitting the final grades for Methods II, I was unable to begin any transcription or coding. I did provide all TCs feedback on their coursework so I was able to note which students were struggling with the coursework and their internships, which in part, helped determine the selection of the case study participants.

Transcribing and Coding Recordings

The case study participants were identified on December 29th, 2014 after the final Methods II grades were submitted. I began transcribing the available data sources (e.g., Audio 1, 2, 3, and Video 1 and 2) that day and continued throughout the month of January. I chose to transcribe all of the data sources for one candidate at a time. This allowed me to write memos and to note potential trends in the discourse practices for each candidate. Each candidates' data took between 10 and 20 hours to transcribe, depending on the speed at which they spoke and the length of their recordings. Once all of the available data were transcribed, I began the coding process. I initially used Dedoose qualitative software for coding; however, after spending several months I switched to MAXQDA software, which had more features (e.g., lexical search) and fewer bugs.

Coding for question types. A deductive coding approach was applied to each of the transcripts. I began a trial coding on Audio 2, since that was the shortest data source

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that occurred within the field placement. I initially attempted to code question types and discourse moves concurrently, but soon realized this was too much to manage. I decided to focus on the question types first, since this had more categories. Unlike my method of transcribing the data, I chose to initially code Audio 2 for all of the participants, so that I could troubleshoot any coding issues arose that were unique for particular candidates.

Each question posed by the TCs was coded using the nine question types identified by Boaler and Brodie (2004) and shown in Table 4. Questions that did not pertain to the lesson (e.g., "Jason, can you sit down please?" or "Does anyone know where Tonya is?") were not coded as questions. However, some statements that technically were not questions, such as statement with a "right?" inserted at the end were coded as questions if the students were expected to respond. One issue that arose was the posing of several questions back-to-back without time for student input. A TC often did this if they were rephrasing their original question. For example, "why can't it be a straight line, why can't it be linear" was identified as only one question, since the students did not have the opportunity to respond between the posing of each question.

Coding nine questions types was troublesome at times for many reasons. Each question could not be interpreted independently of the conversation and context it was used. For example, without context, the question "So which coupon do you guys hope to get?" could potentially be used to gather information, establish context, or explore mathematical relationships. The nine different codes made the coding process time consuming and frustrating and it was not obvious that this level of specification was needed.

Table 4

Nine Question Types (Boaler & Brodie, 2004, p. 777)

	Question Type	**Description**	**Examples**
1	Gathering information leading students through a procedure	Requires immediate answer. Rehearses known facts/procedures. Enables students to state facts/procedures.	What is the value of x in this equation? How would you plot that point?
2	Inserting terminology	Once ideas are under discussion, enables correct mathematical language to be used.	What is this called? How would we write this correctly?
3	Exploring mathematical meanings and/or relationships	Points to underlying mathematical relationships and meanings Makes links between mathematical ideas and representations.	Where is this x on the diagram? What does probability mean?
4	Probing, getting students to explain their thinking	Asks student to articulate, elaborate, or clarify ideas.	How did you get 10? Can you explain your idea?
5	Generating discussion/ Prompt for further participation	Solicits contributions from other members of the class.	Is there another opinion about this? Does anyone want to add to that? Mary, what do you think?
6	Linking and applying	Points to relationships among mathematical ideas and mathematics and other areas of study/life.	In what other situations could you apply this? Where else have we used this?
7	Extending thinking	Extends the situation under discussion to other situations where similar ideas may be used.	Would this work with other numbers?
8	Orienting and focusing	Helps students to focus on key elements of the situation in order to enable problem solving.	What is the problem asking you? What is important about this?
9	Establishing context	Talks about issues outside of mathematics in order to enable links to be made with mathematics.	What is the lottery? How old do you have to be to play the lottery?

Additionally, I struggled to identify between specific codes. For example I often

was left wondering whether an instance was an example of *exploring mathematical*

meanings and/or relationships (Question Type 3*)*, or *linking and applying* (Question

Type 6). For example, consider the following question: "So 1/5th represents how much of an orange?" This question was asked within the context of using manipulates, so one could argue the teacher candidate was linking the mathematical idea to the manipulative or that she was exploring the idea of the whole. However, I continued coding and flagged questions that I was unsure of or that I felt I could justify two different categories. Upon analysis of the initial coding, it became clear that many of the codes were not occurring frequently enough (i.e., Type 2, 6, 7, and 9) to justify such a complex coding scheme. While the nine types helped me identify the lack of *Linking and Applying* questions (Type 6) across all teacher candidates, I was uncomfortable and felt some of the codes were too subjective. Furthermore, I shared the initial results from the nine-question coding analysis with the teacher candidates during my last interview and found it to be too complex for teacher candidates to get a sense of their overall questioning practices.

The focus of the methods courses was to encourage the teacher candidates to move behind question Type 1 and to promote question Types 3, 4, and 5. With this in mind, I decided to condense the coding scheme. Not wanting to over simplify the question types (e.g., open vs. closed), I decided to use the categories presented in a recent NCTM publication. *Principles to Action* (2014) identifies four question types: gathering information, probing thinking, making the mathematics visible, and encouraging reflection and justification. I found I was able to condense my previous nine-question coding scheme to these four codes as shown in the Table 5. This new condensed coding scheme eliminated my previous issues with attempting to distinguish between particular codes (e.g., Type 3 vs. Type 6; Type 1 vs. Type 8). I revisited each of the data sources for Jack and recoded using the new condensed coding scheme to see if any issues arose. The

nine question types condensed to four nicely, eliminating my previous discomfort with

ambiguous questions.

Table 5
Condensed Questions Coding Scheme Alignment

Question Types (NCTM, 2014)	Question Types (Boaler & Brodie, 2004)
Gathering Information	1. Gathering information leading students through a procedure
	2. Inserting terminology
	8. Orienting and focusing
	9. Establishing context
Probing Thinking	4. Probing, getting students to explain their thinking
	5. Generating Discussion
Making the Mathematics Visible	3. Exploring mathematical meanings and/or relationships
	6. Linking and applying
Encouraging Reflection and Justification	7. Extending thinking

Coding for discourse moves. Each transcript was coded for specific discourse

moves that were identified in course readings (Smith & Stein, 2011): (1) revoicing; (2)

asking students to restate someone else's reasoning; (3) asking student to apply their own

reasoning to someone else's reasoning; and (4) prompting students for further

participation. The three videos that were recorded were also coded for an additional

move: wait time. Initially, I attempted to code the audios for wait time; however, I found

this to be problematic since it was unclear why a pause occurred. For example, a teacher

may have paused due to an interruption (e.g., to deal with a behavior issue) or simply

because they lost their train of thought or were distracted. The wait time that is employed

as a discourse move is deliberate and I found this too difficult to determine with only an

audio recording. Table 6 provides examples of each of the discourse moves.

Table 6

Discourse Moves (Chapin, O'Connor, & Anderson, 2009)

	Discourse Move	Description	Example
R	Revoicing	Teacher restates a student comment, may or may not verify with student.	So, Brian, I hear you saying that you think the area will change.
E	Restate someone else's reasoning	Teacher asks another student to restate a students comment. This is not an attempt to interpret or critique.	Diana, can you restate what Brian just said about the diagram?
A	Apply someone else's reasoning	Teacher asks a student to try to compare their reasoning to another students' thinking.	Does anyone agree or disagree with Sean's comment?
W	Using Wait time	Providing time for the entire class, or an individual student to think.	An intentional pause.
P	Prompting for further participation	Asking another student to join the conversation	Did anyone want to add on to that?

As discussed in Chapter 2, several researchers define discourse moves, specifically revoicing, differently. Since this research involves teachers in classrooms, I decided to take the broader definition of revoicing that allows for various forms and functions: "the reuttering of another person's speech through repetition, expansion, rephrasing, and reporting" (Forman, McCormick, & Donato, 1998, p. 531). This means a teacher may simply repeat a student's comment or computation (e.g., linear) or crystalize a main point.

It was feasible for a question to be coded as both a question type and a discourse move. For example, "Brian, did you want to add on to that?" would be coded as a question that tries to generate discussion as well as a discourse move to prompt further discussion.

Transcript analysis. After the five transcripts were coded, the data were explored for themes using MAXQDA as well as Microsoft Excel. Graphical displays of the counts for question types and discourse moves were explored for each candidate across all of the recordings to reveal common trends or shifts for the individual candidates. The raw counts were also explored by each recording to see if there were patterns across the candidates. Then, I returned to the transcripts to explore trends within particular question types or discourse moves. Using MAXQDA, I was able to pull all examples of specific question types and discourse moves across the candidates or by individual candidate to see if there were common phrases or forms of these discourse practices. Lastly, I was able to do a lexical search for these common phrases (e.g., "add on") and other key words.

Analysis of Written Analyses, Reflections, and Interviews

There were six written analyses that corresponded with the recordings, two course reflections, and two interview transcripts. All of these documents were imported into MAXQDA and coded for comments regarding the methods course and comments regarding tensions experienced.

The transcripts were coded for comments regarding learning or general helpfulness and well as frustrations and ineffectiveness experienced during the methods course activities. The documents were also explored for general tensions. Once common themes emerged (i.e., time and resources) the documents were recoded using these themes.

The written analyses were explored for comments regarding student thinking. I was not able to interview each TC after each recording, because the case selection had

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not occurred yet. So I was not able to question them about what they noticed or why they responded in certain ways regarding to student thinking. I instead relied on comments made within the written analyses as well as episodes in the transcripts where student thinking was shared.

Validity and Reliability

One critique of case study as a methodology is the "integrity of the investigator" (Merriam, 2009, p. 52). In a case study, the researcher plays a substantial role in data collection and analysis. This is especially true in this research because I served as both the researcher and instructor. This dual role is not necessarily a limitation. In fact, some scholars argue that the teacher-researcher role provides a unique "insider" perspective to research (Ball, 2000). While the insider perspective can be valuable, I proceeded cautiously to ensure the validity and reliability of my study. To do this, I left an audit trail, or "a detailed account of the methods, procedures, and decision points" (Merriam, 2009, p. 229) through analytic memos. I also used the one-on-one interviews as a form of member checking for tentative findings. Lastly, I presented drafts of the case study chapters to my colleagues throughout their development to ensure that the data presented substantiated my claims.

Chapter 4: Methods I and Methods II

This chapter will provide the reader with an overview of the Methods I and Methods II courses. While the methods courses per se are not the phenomena of interest in this research, they serve as context to help the reader understand the types of activities that the teacher candidates experienced. My intent in this chapter, is, therefore, not to provide a comprehensive description of the methods courses. I begin by providing an overview of both methods courses.

The next section of this chapter is broken into the four components of the learning cycle: representations of practice, approximations of practice, enactments, and investigations of practice. I describe the types of pedagogies that were used to support each component and provide the reader with brief examples taken from the courses (see Figure 5 below). It should be noted that the methods courses were not created around the learning cycle, instead I use the learning cycle to describe the courses in an attempt to respond to the common language call from the field.

I use the last part of the chapter to explain to the reader how the pedagogies from the various components of the learning cycle were woven together to provide opportunities for the TCs to learn about, practice, and reflect on the three mathematics teaching practices (MTP) central to this study-- facilitate meaningful mathematics discourse, pose purposeful questions, and elicit and use evidence of student thinking. To do this I describe the pedagogies used during the class sessions that directly focused on the three MTP.
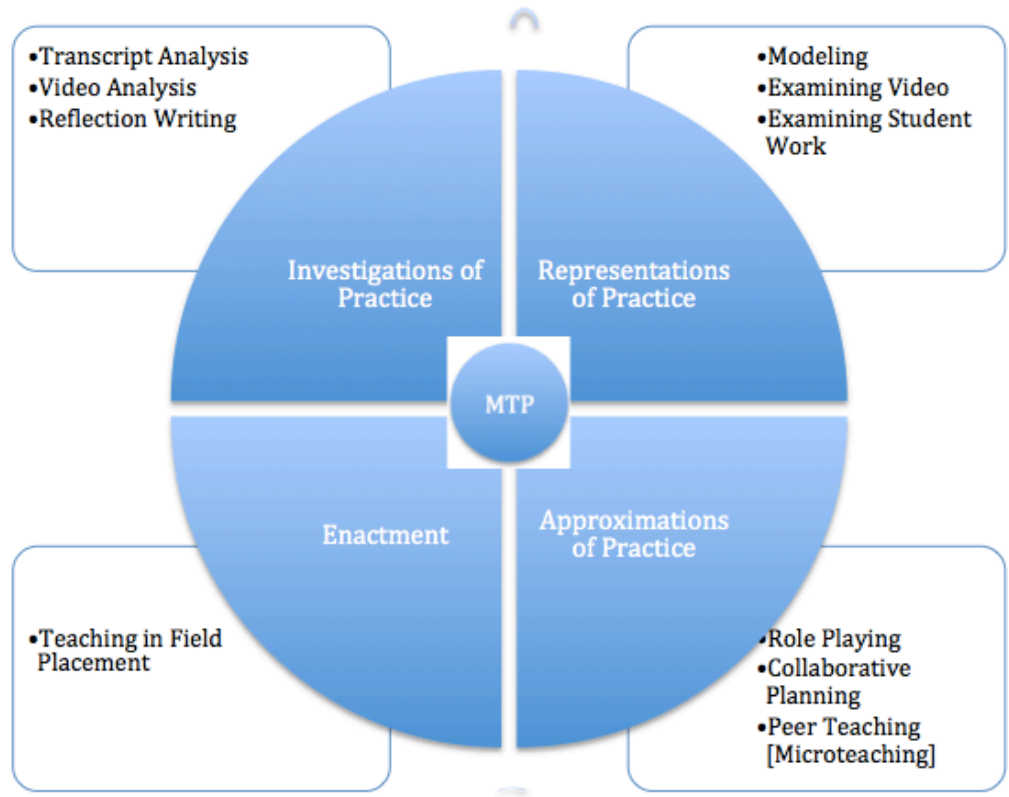
Figure 4. Adapted Cycle for Learning MTP

Overview of Methods I

The first mathematics methods course, Methods I, took place during the summer prior to the teacher candidates' field placement. This course met three hours a day, four days a week, for four consecutive weeks. Methods I is focused on middle school mathematics content and ambitious teaching. The first week of the course served as an introduction to the current state of mathematics education (e.g., CCSSM). The second week began with an introduction into lesson planning, selecting and launching a high-level task, effective questioning practices and concluded with a focus on responding to student thinking. The beginning of week three integrated the components of week two by exploring how to orchestrate a productive mathematics discussion, while also discussing

the role of assessments and how to incorporate tools and technology. Week four provided an opportunity for the teacher candidates to put all of these skills and practices into action through the facilitation of a high level task with their peers.

Methods I focused heavily on *representations of practice* with opportunities for the TCs to implement two *approximations of practice* and two *investigations of practice*. While the first methods course continuously revisits the MTP, there are three particular class sessions during which they are the main focus: Session 7- Questioning practices, Session 8- Responding to student thinking, and Session 9- Orchestrating productive mathematics discussion. See Appendix J for an overview of the components of the learning cycle by course session.

Overview of Methods II

The second mathematics methods course, Methods II, met one evening a week for fourteen weeks during Fall 2014. While Methods I used middle school mathematics as a context for learning, Methods II focused on secondary mathematics more broadly. In an attempt to meet the needs of both the teacher candidates seeking middle school certification as well as those planning to teach high school, I chose Algebra to be the content focus because Algebra is offered at both the middle and high school levels.

While the pedagogies used during Method II were similar to those in Methods I the concurrent field placements impacted the type and frequency of use. I intended to make Methods II as relevant as possible to the TCs' field placement and overall experience. For example, the class explored fewer mathematical tasks, showed fewer videos, and included no role-playing or peer teaching. Instead I asked TCs to explore artifacts (e.g., audio and video) from their own classrooms and to conduct a lesson study

with peers who were assigned to teach the same grade level. While Methods II revisited the three MTP, two class sessions addressed them specifically: Session 5 and Session 6. See Appendix K for an overview of the phases of the learning cycle by course session.

Representations of Practice

According to Grossman and colleagues (2009) "Representations of practice comprise the different ways that practice is represented in professional education and what these various representations make visible to novices" (p. 2058). Methods I and Methods II used three main pedagogies to provide representations of practice: modeling, examining video exemplars, and examining sample student work. Whenever possible I attempted to use multiple pedagogies to present specific practices of teaching. For example, I had the TCs work a high-level task, then watch a video of students working on the same problem or perhaps explore samples of student work. I employed these pedagogies to help TCs learn about a specific teaching practice (e.g., posing purposeful questions). I repeatedly used these pedagogies but they served different purposes given the focus of the class session. Below I describe the three pedagogies and provide examples from the courses.

Modeling

It is crucial that the teacher candidates have an opportunity to experience ambitious teaching as learners, prior to expecting them to teach in this way (CBMS, 2012; Curcio, Schwartz, & Brown, 1996; Silver & Smith, 1996). It is assumed that Methods I will be the teacher candidates' first experience in a mathematics class that focuses on discourse and student thinking. Thus modeling—via rich mathematical tasks—is one of the most frequently used pedagogies.

Rich, or worthwhile, mathematical tasks are defined as "tasks that often lend themselves to multiple solution methods, frequently involve multiple representations, and usually require students to justify, conjecture, and interpret" (Silver & Smith, 1996, p. 24). These tasks are often said to have a 'low-floor' (i.e., all students can access) and 'high ceiling' (i.e., can extend to high levels) (Boaler, 2016). These types of mathematical tasks can be used to push TCs to go beyond common content knowledge and simply solving a problem toward a deeper understanding of the content needed for teaching. TCs can explore possible student solutions and potential misconceptions, which further develops their mathematical understandings. Moreover these mathematical tasks serve a context for the instructor to model ambitious teaching. See Appendix L for a table of mathematical tasks worked during Methods I and Appendix M for tasks worked in Methods II.

Each time I facilitated a mathematical task in the methods course I attempted to model teaching practices. For example, I often modeled the *Five Practices for Facilitating a Productive Discussion*: anticipate, monitor, select, sequence, and connect (Smith & Stein, 2011). A typical mathematical exploration began with teacher candidates exploring the task individually and then discussing their work in small groups of 3-4. While students worked individually and in small groups, I walked around and *monitored*. This means I took note of various student solution techniques as well as their comments. Occasionally, I posed questions for clarification or provide an extension task, but most of the time I simply listened to the TCs' discussion. This individual work time typically lasted between 2 and 10 minutes, and group work time spanned anywhere between 5 minutes and 15 minutes, depending on the task.

During this small group work time, I *selected* and *sequenced* the TCs' work in preparation for a whole-class discussion centered on their mathematical thinking. Often times I sequenced the work starting from a pictorial representation and ending with an algebraic formula or manipulation. This helped the TCs *connect* the various representations. Initially, many of the TCs struggled to think beyond an algebraic approach, so I constantly challenged them to produce multiple representations. Specifically, I encouraged them to create a pictorial representation that could convince a middle school student who has not had a formal algebra class. The TCs, particularly the career changers, enjoyed the challenge of trying to think about the task in a more conceptual manner.

After the mathematical exploration, the teacher candidates were asked to 'switch hats' and to explore the task from a teaching perspective. As a class, we discussed the various teaching moves and practices that I modeled. These discussions depended on the objectives of each particular class session (e.g., posing purposeful questions). I tried not to reveal too much at once, but assured the TCs that there was a reason behind each decision that I made. As the course unfolded we continued to unpack my practice and often refer back to some of my actions during previous mathematical tasks. Below I more clearly explain the types of mathematical tasks used for modeling.

Examining Video Exemplars

During Methods I, I drew from three video sources: Boaler and Humphries (2005), INVEST video collection from Lipscomb University, and the TIMSS video collection. We revisited these video sources several times throughout the course depending on the topic of the day. During Methods II, I used video clips from Annenberg

Learner, the Teaching Channel and TIMSS. Prior to watching classroom video the TCs were typically asked to work the mathematical tasks so that the mathematics would not be a distraction allowing them to focus on the teaching practices.

We typically did not watch an entire classroom video during the methods class. Instead, the clips were broken into smaller segments that aligned with different foci of the course sessions. Take for example, the Border Problem, an exemplar video from *Connecting Mathematical Ideas* (Boaler & Humphries, 2005) used during the Methods I. The TCs were exposed to the Border Problem though a classroom vignette (i.e., role-playing) during week one while exploring examples of the Common Core Standards for mathematical practices (Koestler, Felton, Bieda, & Otten, 2013, p. 7-9), so the TCs already examined various student solutions to the task. The Border Problem video was broken into the following segments: focus on the launching of the task (0-0:55), recording student thinking (1:00-6:00), explaining Zak's method (6:00-8:30), connecting representations (8:30-11:15), and extending thinking to a new problem (11:15-12:30). Thus, this video is used over several class sessions to highlight different teaching practices.

Examining Student Work

Another pedagogy that was used as a representation of practice was examining sample student work. Similar to the use of videos, I typically asked TCs to work a mathematics task prior to viewing student work. Often times the student work shown was from articles that the TCs would read that correspond with mathematical tasks completed during class (e.g., Kuper & Kimani). For example, during Session 4 of Methods I, I facilitated the exploration of the Bag of Marbles Task. We then revisited this task and the

accompanying student work twice. First, we explored the student work during Session 5 when we focused on lesson planning. Smith, Bill and Hughes (2008) use the Marble Task to introduce the Thinking Through a Lesson Protocol. This protocol presents the teacher with several prompts to think through prior to the lesson. For example, the protocol encourages TCs to use anticipated student solutions to create questions to pose so that one can both assess and advance students' thinking. We then revisited the student work when we talked specifically about the Five Practices for Facilitating Productive Discussion during Session 9. Again we use the student work for the Marble Task (Smith, Hughes, Engle & Stein, 2009), but this time we discussed the sequencing of student solutions.

Approximations of Practice

Approximations of practice provide "opportunities for novices to engage in practices that are more or less proximal to the practices of a profession" (Grossman, Compton, et al., 2009, p. 2058). There are three different pedagogies used in the methods courses that provided TCs opportunities to approximate the practices of ambitious teaching: role-playing, teaching a peer lesson, and lesson study. The peer lesson serves as a data source for this research and was previously described in Chapter 3 (see Appendix D).

Role Playing

The TCs participated in two role-playing activities during Methods I. The TCs audio recorded the second role-playing activity, which was previously discussed in Chapter 3 (see Audio 1). The first role-playing activity occurred at the end of week one (Session 3 and 4) of Methods I and will be discussed here. The TCs were divided into

groups and assigned one of the Standards for Mathematical Practice (SMP). They were then given a chapter from *Connecting the NCTM Process Standards and the CCSSM Practice* (Koestler, Felton, Bieda & Otten, 2013) to read and they were asked to position themselves as the class "experts" on that particular SMP. They were expected to enact a vignette from their chapter for their peers and to lead a discussion about how the SMP was evident in their enactment and how it related to other SMPs. For example, one group was assigned SMP 1 (i.e., Make Sense of Problems and Persevere in Solving Them) and was assigned a middle school vignette depicting a teacher facilitating a whole class discussion about the Border Problem (Koestler, Felton, Bieda & Otten, 2013, p. 7-9). These vignettes allowed the teacher candidates to enact ambitious teaching practices (e.g., elicit and build on student thinking), without having been formally introduced to them.

Lesson Study (Collaborative planning)

The lesson study was a substantial component of the Methods II. Each grade-level group was provided class time to apply content that was explored during each methods class session (e.g., setting learning objectives, posing questions) to their lesson study. For example, Session 4 focused on setting learning objectives that were clear and measurable, so each lesson study group was expected to have a draft of their lesson objectives at the completion of that session. This type of scaffolding continued throughout the course. Each of the teacher candidates was asked to enact their group lesson plan in their field placement with their peers serving as observers. Then, the lesson study group debriefed their enactments and observations. The lesson study culminated with a group

presentation for their peers, which provided an overview of their lesson and highlighted what they learned about student thinking.

Enactments

Enactments occur when the TC can practice teaching with real students. This may include co-teaching or coaching by the mentor or methods instructor. However, an important component of the enactment stage is creating a record of the practice (e.g., audio or video recording) (McDonald, Kazemi, & Kavanagh, 2013). The record can later be explored as an investigation of practice. Recall that the TC did not have access to real students in Methods I, so no enactments occurred. However, TCs conducted three enactments during Methods II. Two of these were audio recorded and one was video recorded. These were all previously discussed in Chapter 3.

Investigations of Practice

Investigations of practice provide TCs the opportunity to analyze the practice of teaching. This may include an analysis of their own teaching via recordings or other artifacts, or it could be the analysis of other teachers. There were three pedagogies utilized during Methods I and II to conduct investigations of practice: transcript analysis, video analysis, and reflection writing.

There were many instances of informal transcript and video analysis in both methods courses. Students were asked to explore classroom transcripts at several points during both methods courses. Some of these explorations were done as whole class discussions (e.g., Methods I- Session 3 SMP role playing; Methods II- Session 5- Growing Staircase) while others were components of out of class readings. Several of the transcripts in the readings focused on teacher questioning practices and provided

suggestions for ways to improve classroom dialogue (e.g., Arbaugh & Avery, 2009; Herbel-Eisenmann & Breyfogle, 2005; Manouchehri & Lapp, 2003). Similarly, the candidates were asked to informally analyze videos that were watched in both methods classes. While many informal verbal analyses occurred after reading transcripts and watching classroom video, two analyses in Methods I included a formal written reflection and three in Methods II. These written reflections served as data for this research and were previously described in Chapter 3.

Methods I and II Sessions that Emphasized the Mathematics Teaching Practices

In this section I provide the reader with an overview of the class sessions that were directly focused on the three MTP. Again, I draw on the common language from the learning cycle; however, I include one additional category—decompositions. "Decomposition of practice involves breaking down practice into its constituent parts for the purposes of teaching and learning." (Grossman, Compton et al., 2009, p. 2058). In this sense, many of our course readings identified specific moves (e.g., wait time) and I see these as a way to help the teacher candidate break down the MTP we explored.

Methods I

Recall that the pedagogies used during Methods I and Methods II differed due to university constraints. Both courses provided the teacher candidates with readings that identified components of the MTP, samples of student work, and classroom videos. However, during Method I the TCs did not have access to students and they were not able to conduct any enactments. Table 7 offers the reader an overview of class sessions 7, 8, and 9 of Methods I and the various pedagogies that were used.

Table 7

Overview of Methods I Sessions and Assignments that Emphasized MTP

	Methods I June 2014			
Class Session	**Session 7: Questioning Practices**	**Session 8: Eliciting & Responding to Student Thinking**	**Session 9: Five Practices for facilitating productive discussion**	**Session: 13-15**
Date (2014)	June 11th	June 12th	June 16th	June 23rd -26th
Decompositions	Articles (2)	Article (1)	Articles (2)	
Representations of Practice	Modeling Examining Videos (3)	Examining Student work (2)	Examining Videos (2) Examining Student work	
Approximations of Practice		Role Playing Audio #1		Peer-teaching
Enactments				
Investigations of Practice		Audio Analysis #1		Video Analysis #1

Key:
Facilitating meaningful mathematics discourse, Posing purposeful questions, Elicit and use evidence of student thinking,
Both- Posing purposeful questions AND Elicit and use evidence of student thinking
All three practices

Session 7: Questioning practices. Session 7 provided students with two articles that decomposed aspects of question posing, a mathematical task through which the five practices were modeled, and three videos, which were used as representations of practice. In preparation for Session 7, I asked TC to read two articles: "Questioning our Patterns of Questioning*"* (Herbel-Eisenmann & Breyfogle, 2005) and "Unveiling Student Understanding: The Role of Questioning in Instruction" (Manouchehri & Lapp, 2003). The former article introduced TCs to the broad discourse pattern of Initiation-Response-Feedback (IRF) as well as questioning patterns such as *focusing* and *funneling*. The latter article introduced candidates into designing and analyzing questions for *form* (e.g., open or closed), *content* (e.g., mathematical and instructional goals), and *purpose* (e.g., assessing procedural or conceptual understanding).

Session 7 began with a fraction subtraction problem that is typical of many traditional textbooks (e.g., 3½- 2/3). Instead of asking the teacher candidates to simplify the expression, they are tasked with creating a story problem that could be represented by the expression (see Rathouz & Rubenstein, 2009). This prompt was chosen to show that one can take a traditional computational problem and create a rich mathematical discussion by changing the question posed. It also allowed the teacher educator to model some of the five practices (i.e., monitoring, selecting, sequencing). After exploring this task the TCs were then shown a video of a middle school classroom where a veteran teacher tried to think of a scenario for this prompt in-the-moment (i.e., The Division Problem). The TCs appreciate this video because the teacher experienced some of the struggle they encountered. Two other videos were used during Session 7 (e.g., The Border Problem and The Surprising Square Task) that depicted teachers posing questions while monitoring student work.

Session 8: Eliciting and responding to student thinking. Session 8 used articles to identify various discourse moves, student work as a representation of practice, and a role-playing activity as an approximation of practice. Prior to the session, the TCs were asked to read "Discourse: Simple Moves that Work" (Rawding & Wills, 2012). This article introduced TCs to the importance and challenges of creating a discourse community. It provided various discourse moves such as "turn and talk", repeating and rephrasing, as well as ideas for sentence stems (e.g., I agree with _____ because…) to post around the classroom.

During Session 8 the TCs were provided samples of student work that contained errors. As a class we examined a student error around multiplication of mixed numbers.

We worked to make sense of what the student did and discussed how we would respond to this student. Then, the TCs explored a second student work sample that was associated with a fraction addition task. This was the task that was used for the peer role-playing activity described in Chapter 3. Recall that the TCs were challenged to apply productive questioning practices to make sense of the student's thinking that was represented in the work sample. The goal of this approximation of practice was to create an opportunity for TCs to think on their feet and respond to student work in-the-moment. The teacher candidates were asked to audio record this conversation. This artifact was used for the investigation of practice. Each of the TCs was asked to analyze the questions they posed and identify what they learned about the student thinking.

Session 9: Orchestrating productive mathematics discussion. Session 9 offered two additional readings that decomposed various aspects of classroom discourse, and two representations of practice. The first article, "Never Say Anything a Kid Can Say" (Reinhart, 2000) provided a list of suggested techniques to encourage discourse and student thinking (e.g., think-pair-share, ask open ended questions, never carry a pencil). The second reading, "Orchestrating Discussions" (Smith, Hughes, Engle, & Stein, 2009), reintroduced the Five Practices for Facilitating a Productive Discussion (e.g., anticipate, monitor, select, sequence, connect).

These readings were complemented with the examination of videos. The Division of Fractions video and The Surprising Square Task were revisited. For example, while watching the video the TCs were asked to take note of student comments and the discourse moves the teacher made during the whole class discussion. This allowed us to discuss the teacher's discourse moves, such as wait time, and we were also able to see the

way the teacher responds to student thinking. For example, in this Division of Fractions video the teacher responded to an incorrect student idea, which happens to be the first comment shared in the whole class discussion. We also see the way the teacher responded to a student who was persistent in applying a known procedure (e.g., invert and multiply). Not only do TCs see a veteran teacher respond in-the-moment to student thinking, they also notice several classroom discourse norms. For example, several TCs noted that they liked a particular phrase used by the teacher --"convince yourself, convince a friend, convince a skeptic."

Methods II

Since the TC took Methods II and were concurrently in field placements, we used artifacts from their classrooms when possible. We also do not have any approximations of practice. Table 8 offers the reader an overview of class sessions 5 and 6 of Methods II and the various pedagogies that were used.

Session 5: Anticipating student responses. Prior to Session 5 the teacher candidates were asked to read two documents. One article titled "Focusing on Students Mathematical Thinking" (Breyfogle & Herbel-Eisenmann, 2004), reinforced the notion of wait time as well as "pressing" for student thinking. It provided a brief classroom transcript to show a missed opportunity to have a student elaborate their thinking. The second reading was a chapter from Smith and Stein (2005) that addressed anticipating students' responses and monitoring their work.

Table 8

Overview of Methods II Sessions and Assignments that Emphasized MTP

Class Session		Session 5: Anticipating Student Responses	Session 6: Classroom Discourse		
		Methods II September 8th- December 8th, 2014			
Date (2014)	September	October 6th	October 12th	Late October	Early December
Decompositions		Article (1) Article (1)	Article (1) Article (1)		
Representations of Practice		Modeling Examining Video (1) Examining Student work/transcript Case study	Modeling Examining Transcript		
Approximations of Practice					
Enactments	10-min Recording			50-min Recording	15-20 min Recording
Investigations of Practice	Audio Analysis #2			Audio Analysis #3	Video Analysis #2

Key:
Facilitating meaningful mathematics discourse, *Posing purposeful questions*, *Elicit and use evidence of student thinking*,
Both- Posing purposeful questions AND Elicit and use evidence of student thinking
All three practices

After debriefing on the articles, the TCs were asked to work a mathematical task referred to as the Growing Staircase. Again, the instructor modeled the five practices via the task. The TCs were then asked to explore student thinking via two classroom transcripts provided by the Annenberg Foundation. In the first transcript a teacher responded to a student error and the second depicted a teacher responding to a student idea to work backward on the task. The teacher's comments and questions were discussed and then the TCs were shown a video of students working the same task. The video showed the way a teacher responded to a student who tried to use a brute force approach

to the problem. Both the transcripts and the videos were used to depict scenarios where teachers were eliciting and using evidence of student thinking.

Session 6: Classroom discourse. There were three readings that the TCs were asked to complete prior to Sessions 6. All three readings contain transcripts and advice to explore classroom discourse. The first article "Let's Talk: Promoting Mathematical Discourse in the Classroom" (Stein, 2007), presented the TCs with examples of high press and low press classrooms. It also presented the idea of motivational discourse and the ways in which a teacher's comments can encourage or discourage student participation. The second article "Enhancing the Learning Environment through Student-led Mathematical Discussions" (Arbaugh & Avery, 2009) presented a transcript from a high school classroom where the students led the discussion and the teacher facilitated from the back of the classroom. This article also offered the teachers voice in the struggle to create an environment where student-led discussion could occur. The third reading was a book chapter entitled "Examining Lining Growth Patterns: The case of Catherine Evans and David Young" (Smith et al., 2005). The chapter depicted the same mathematical tasks being enacted by two teachers. These contrasting cases were used to show the way in which a task is implementation can impact the cognitive demand level.

After debriefing on the content of readings, teacher candidates were asked to complete a task sorting activity called "Always, Sometimes, or Never True". Again, the instructor modeled some of the five practices (i.e., Anticipate, Monitor, Select, and Sequence) around one common misconception regarding square roots (see Grosser-Clarkson, 2015). The teacher candidates were also provided video representation to see this being enacted in a real classroom.

Chapter 5: Jack's Shift from Leader to Facilitator

In this chapter I present the reader with the case of Jack and his progression in his facilitation of meaningful mathematical discourse. Jack consistently used many discourse moves and question types throughout the program; however, the frequency and the way he used them gradually shifted as Jack took on more of a facilitator role in the classroom discourse. At the beginning of the program Jack played a dominant role in the classroom discourse. That is, he did the majority of the explaining, summarizing, questioning and evaluating. While Jack asked for student input he appeared to be more interested in correct answers than in student thinking behind the answers. However, Jack gradually transitioned from being the mathematical authority toward providing more ownership to the students and their ideas. By late Fall Jack relied more on student explanations and allowed students to evaluate each other's comments.

In order to help the reader get a sense of Jack's gradual shift in his role in the classroom discourse, I provide two longer excerpts taken from his field placement. I begin with the transcript from an early audio recorded in September. I identify the way Jack took up student thinking in this clip, the question types and discourse moves he used and then summarize his overall discourse patterns. I then provide a second excerpt taken from the transcript of the video recorded in March. I highlight the consistencies and, more importantly, I discuss the changes noted in Jack's classroom discourse practices between the episodes. When needed, I also draw examples from the other data sources to strengthen my claims. I conclude the chapter by exploring aspects of discourse in Jack's ideal classroom.

To remind the reader, below is a chart summarizing the audio and video data

sources and the context in which they were recorded, the length of the recording, when they were recorded, and the key mathematical idea explored in the recording. Before I take the reader into Jack's classroom, I first provide an introduction to Jack and an overview of his school and classroom context.

Table 9

Summary of Jack's Audio and Video Data Sources

Type of Recording-Context	Length of Recording (minutes)	Month Recorded	Key Mathematical Idea
Audio- Peer Role Play	5	Early June 2014	Fraction Addition
Video- Peer Lesson	70	Late June 2014	Proportionality
Audio- Field Placement	21	Late September 2014	Types of Numbers
Audio- Field Placement	58	Late November 2014	Scientific Notation
Video- Field Placement	15	December 2014	Reflections
Video- Field Placement	20	March 2015	Linear Regression

A Brief Introduction to Jack

Jack, a male in his mid-twenties, was enrolled in the ALT program. He graduated in 2011 from a small private liberal arts college with a bachelor's degree in Chemistry and dual minors in Mathematics and Education. While in college, Jack participated in athletics and according to several newspaper accounts he was a key contributor to his team. Following graduation Jack tutored and worked as a substitute teacher. Jack entered the program with strong perceptions of public school teaching as well as the current CCSSM climate due to interactions with his mother, who was a career-long educator.

While Jack admitted he never gave his full effort in his previous academic studies,

he positioned himself as a knowledgeable student and teacher of mathematics from the first day of the methods class. He appeared comfortable and confident when explaining mathematics to his peers as well as his students and noted that he "enjoy[ed] doing mathematics" (Methods I Course Reflection, p. 4). Jack identified one of his assets as his "strong knowledge of how math works" (p. 4), but he also recognized this as a potential weakness, noting, "that sometimes I understand math so quickly that I may not understand why students are having trouble understanding" (p. 5). This was evident when Jack would occasionally become frustrated with both his students and his peers if they struggled to follow his reasoning or produced incorrect answers.

School and Classroom Contexts

Jack's field placement was in a large suburban district at a public middle school, Hillside Middle School, which served approximately 850 students in grades 6-8 (www.nces.ed.gov 2013-2014 school year). Hillside Middle School is a Title I school and served a predominately Hispanic community. Approximately 67% of the student body were Hispanic, 28% were Black, 3% were Asian/Pacific Islander, and approximately 1% were White. Approximately 78% of the students were eligible for free lunch and about 11% were eligible for reduced-price lunch. Hillside Middle School was part of a district technology initiative and each student was provided with an iPad. Jack's classes met for 65 minutes each day and consisted of eighth-grade students who were labeled as honors. Since Jack was enrolled in the ALT program he was the teacher-of-record for half of the school day.

Episode I

The excerpt below was taken from the 21-minute audio recorded during Jack's field placement in late September. This recording was chosen because it was the first data source taken from Jack's field placement and it was representative of the types of things that appeared in his early recordings. For example, it became evident in Jack's early data sources that his strong mathematical content knowledge allowed him to quickly process student comments and provide counterexamples in-the-moment. In this segment, Jack identified and used a counterexample (i.e., 6/5ths) to try to help students experience cognitive conflict. Jack also used a variety of question types such as gathering information and probing thinking. Jack also used many discourse moves, such as revoicing, prompting for further participation, and asking a student to apply another student's reasoning. The use of these question types and discourse moves is promising and shows that Jack is attempting to facilitate productive classroom discourse; however, Jack does not elicit student thinking. I interrupt the transcript when this becomes evident and Jack asserts his frustration. It should be noted that Jack's classroom is extremely quiet during this episode and there are almost no audible side conversations.

In this transcript, Jack's students had been introduced to irrational numbers and were working on identifying various types of numbers. Jack had provided his students with a set of multiple-choice questions and the audio captures the discussion as they go over the answers. The five questions that were discussed during the audio are as follows: (1) Which of the following is a whole number? (2) Which of the following is an integer? (3) Which of the following statements is true? (4) Which fraction can be expressed as a

terminating decimal? and (5) Which of the following numbers is irrational? The excerpt

below comes from the discussion around the third prompt.

79[1]	*Jack:*	Which of the following of the statements is true? Now this is a very good question. I really want you to think about this, for a little bit before you answer. (A) All integers are whole numbers, (B) All rational numbers are integers, (C) All whole numbers are rational or (D) All rational numbers are whole numbers. Think about it. I'm gonna ask for hands in a second, but I really want you to be able to defend your answer. Tell me what your thinking is behind this.
80		[students working silently for about 25 seconds]
81	*Jack:*	Somebody want to start us off? What do you think? Student 4, go ahead.
82	*S4:*	(inaudible)
83	*Jack:*	I've got people talking over here and I'm not going to call on them if they are going to talk and can you speak a little bit louder Student 4?
84	*S4:*	It's number 3 [referring to C] because the real--they're saying that all whole numbers are rational numbers.
85	*Jack*	Okay, so you're saying that all whole numbers are rational numbers. Does anybody want to make a comment on that or think something else? [pause] Or do we not really know which one we think?
86	*S:*	[mumbling]
87	*Jack:*	Okay let's go through them. All integers are whole numbers. Do you believe that's true?
88	*S:*	No.
89	*Jack:*	Somebody explain to me why. If you think that it's not true why can all integers are whole numbers not be true, Student 11?
90	*S11:*	Because like integers have both positive and negatives and whole numbers are just positive numbers...
91	*Jack:*	Good, so we know it can't be A because all integers cannot be whole numbers, like your explanation, because integers have negatives. Now B. All numbers are integers. If you don't agree with that somebody tell me why. All rational numbers are integers. [long pause] What it's saying is that all rational numbers are integers. Are there numbers that are rational that are not integers?
92	*S:*	[mumbling]
93	*S:*	Yeah.
94	*Jack:*	So if you can't tell me one way or the other then this is true, right? Nobody can tell me why it's not true. Then B's got to be true as well. [long pause] What do you think?

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[1] This number represents the talk turn from the original transcript.

95	*S:*	What-what one are we on right now?
96	*Jack:*	All rational numbers are integers. Nobody answered except one person to say "C" so we're trying to prove or disprove each choice, Student 12?
97	*S12:*	B, I think it's B because um well rational falls into integers and whole numbers and since integers have positive also- positive and negative and um whole numbers just have positive but since, but since um whole numbers have um only positive integers have positives too so it would be B.
98	*Jack:*	Does anybody want to comment on what Student 12 just said, Student 5?
99	*S5:*	I think I agree because um, um natural numbers um are integers just have to be written as fractions and integers include positive and negative numbers which can also be um used as a rational numbers to be written as fractions.
100	*Jack:*	Okay so now we have two answers that people think it is, who said that it was C before? Student 4, can you tell us why you don't think it's B?
101	*S4:*	[long pause] Cause (inaudible) (Episode taken from Audio 2, 6:09-11:40)

Up to this point, Jack has been using a variety of discourse moves to elicit student responses, however, after this point there is a shift in Jack's tone, and we see a change in the classroom discourse. It seems that he becomes frustrated when the students start providing incorrect answers. In the remainder of the transcript, shown below, Jack switches to more rapid-fire gathering information questions and he no longer is asking for any student explanations. Jack merely wants answers to his fill-in-the-blank questions so that he can lead students to experience cognitive conflict. It is not clear what understanding the students have at the end of this dialogue as Jack ends up telling them the correct answer.

102	*Jack:*	Okay, I'm very disappointed right now that nobody's really trying to be engaged in this at all. You guys are just not paying attention, B is NOT correct, all rational numbers are not integers.
103	*S:*	Exactly.
104	*Jack:*	If you have the number six-fifths is that a fraction?
105	*S:*	Yes.
106	*Jack:*	So is that a rational number?

107	*S:*	No.
108	*Jack:*	Is six-fifths a rational number?
109	*Ss:*	NO, no.
110	*Jack:*	Is six-fifths a fr- can six-fifths be written as a fraction?
111	*S:*	Yes.
112	*Jack:*	It IS a fraction so it's a rational number, right?
113	*S:*	Yes.
114	*Jack:*	Now is six-fifths an integer?
115	*S:*	No.
116	*Jack:*	NO! So I just gave you an example of a rational number that's not an integer right, so can all rational numbers be integers?
117	*Ss:*	No.
118	*Jack:*	No. There are some that aren't. We're going to have a quiz on this on Tuesday...
119	*S:*	Ohhh.
120	*S:*	What?
121	*Jack:*	And people that aren't paying attention, you're just going to have the same problems that you do right now.
122	*S:*	On Tuesday?
123	*Jack:*	Yeah.
124	*S:*	On THIS?
125	*Jack:*	YEAH! I don't see anybody trying to learn it. I see people talking and looking around and doing stuff. You're lucky I don't give it to you right now. C all whole numbers are rational. Whole numbers fit into the big rational group, rationals--the big group, okay? So whole numbers did fit in there so C is the correct answer. All rational numbers are whole number. That can't be true because there are rational numbers that aren't whole numbers, like negative 1. That's a rational number but it's not a whole number, okay?

Elicit and Use Evidence of Student Thinking

In Episode I, Jack never posed questions that allowed him to unpack the students' erroneous classification of numbers and their confusion surrounding rational numbers. Jack was disappointed with his students for what he perceived was a lack of effort and engagement. Jack's frustration led him to ask questions that required yes or no responses and he tried to provide students with a counterexample. However, Jack never elicits comments to help find the root of their confusion around six-fifths or more generally how they were thinking about rational numbers. As an outside observer, it appeared to me that

the students were genuinely confused and uncomfortable with classifying types of numbers. The first three recordings (e.g., June audio, June video, and September audio) all contain examples where Jack did not elicit thinking around incorrect student responses. Below I provide an additional example from the June video.

The analysis that accompanied Jack's June video allowed him to see that he was indeed not pursuing the students' thinking. Jack asked his peers to work on a challenging proportionality task: "If 6 cats can catch and kill 6 rats in 6 minutes, how many cats will it take to catch and kill 100 rats in 50 minutes?" (Markworth, 2012, p. 540). Due to some confusion, Jack responded incorrectly to a few of his peers' initial questions (i.e., that the rates were not constant), which caused frustration for Jack as well as his peers. This is particularly relevant for this section because Jack struggled to understand what his students (i.e., peers) were thinking, which derailed the lesson. Jack made the following observation in his reflection:

> I was trying to "lecture" them on how the problem was working. Beside the fact that I was telling them something that was untrue, I did not allow the students to explore what they were thinking. Some of the students were trying to explore the problem, but I was telling them something that contradicted their thinking. (Video Analysis, p.3)

Jack eventually realized the contradiction in his responses to his peers; however, he only acknowledged this error to one student who, out of frustration, kept pushing him to clarify his statements. Once Jack got himself back on track he was able to pose a variety of questions. In the next section we will explore Jack's questioning practice and how questions were used to lead students to the correct answer rather than to help him

understands student thinking.

Question Types

Jack's early data sources show that he relied heavily on questions that gathered information to lead students through a procedure. This was evident in Episode I after he became frustrated with students around Line 102. He had asked students whether all rational numbers were integers and the students struggled to correctly answer his question. Jack told them that the statement was false and then posed seven simple recall questions in a row to attempt to lead students to see that six-fifths is a rational number and not an integer.

If we look more closely at Line 112 ("It is a fraction, so it's a rational number, right?") we see a common question form used by Jack when leading students through a procedure. Jack's use of the word "right," at the end of a statement to turn it into a yes/no question allows him to continue an explanation or lead students through a procedure without more elaborate student input or derailment. While this may appear to be a rhetorical question to an outsider, the classroom norm that Jack established was for students to respond. Thus, Jack would not continue until students have confirmed that his statement was indeed correct. This pattern of questioning, one that led students through a procedure, was familiar to Jack from his previous mathematical experiences as both a student and a tutor. Jack noted in his Methods I reflection that,

> Before taking [Methods I] if I was asked what effective questioning practices were I would have no idea…I always thought that it was most important that students came to the right answer. In the past I would ask questions that led my students to the answer instead of having them explain their thinking. (p. 2)

Although Jack often resorted to questions that would lead students through a procedure in his early data sources, this was not always the case. Jack did not always evaluate students' comments right away. Prior to the back-and-forth exchange in the latter half of Episode I, Jack had asked several more open-ended probing questions (Lines 81, 85, 89, 91, 94, 96, 98, 100). This included questions that prompted students to explain their thinking as well as questions that solicited contributions from other students. Thus, it is clear that Jack was experimenting with new questioning patterns and initially was trying to use questioning to get the students more involved. However, when students provided the wrong answer and Jack became disappointed he resorted to the types of questions and teacher-student interactions that were more familiar to him.

Discourse Moves

While at times Jack used discourse moves to encourage students to join the conversation, overwhelmingly these early attempts did not generate discussion. Revoicing was the most prominent discourse move used by Jack across all of the data sources (see Appendix O); however, the way he used revoicing varied drastically in terms of generating discourse. Below I describe the three different ways that Jack used revoicing in this episode— repeating for emphasis, rephrasing and evaluating a student contribution, and reiterating a student comment to generate discussion.

Recall that revoicing is defined as "the reuttering of another person's speech through repetition, expansion, rephrasing, and reporting" (Forman, McCormick, & Donato, 1998, p. 531). Jack frequently restated a single word (e.g., yes/no) or a computational response from a student. For example in Episode I, when Jack becomes frustrated and asks rapid fire recall questions, he reiterates student responses "NO" (Line

116, 118). In this use of the move he is simply validating a student's response to a fill-in-the-blank question and is not using it to further the classroom discourse. Some might argue that this is not an example of revoicing; however, research has shown practicing teachers view any form of repetition as revoicing (Krusi, 2009) and thus it was classified as revoicing in this research as was discussed in Chapter 3.

It was common for Jack to use revoicing as a way to evaluate a student contribution in the early data sources. For example, in Line 91, Jack begins by evaluating the student comment "Good" and then revoices the student contribution, although not verbatim. Jack would often include a "right" or "yeah" either before or after the utterance, which shows that he was evaluating the student comment and it was indeed correct. Here one can see the purpose of revoicing is different. Jack is not using revoicing as a technique to encourage more discourse because he has already confirmed the correct solution. Instead, Jack used revoicing here as a way of emphasizing a mathematical point (i.e., all integers cannot be whole numbers). Jack also used this form of revoicing to rephrase student comments to either clarify them or to insert more sophisticated vocabulary.

In Episode I we see Jack revoice a student comment in order to generate discussion. Jack revoiced the following student comment "Okay, so you're saying that all whole numbers are rational numbers" (Line 85). He follows this by asking, "Does anybody want to make a comment on that or think something else?" Unlike the other examples, it is apparent that Jack is using revoicing to see if other students are in agreement.

In addition to revoicing Jack also prompted for further participation and asked a student to apply another student's reasoning. Jack began the episode by using these discourse moves. For example, Jack asked, "Does anybody want to make a comment on that or think something else?" (Line 85), and he also specifically asked another student to "Tell us why you don't think it's B" (Line 100). While these comments by themselves appear to be textbook discourse moves, they do not elicit student thinking in these instances. In Line 98, Jack has a student respond to the following prompt, "Does anybody want to comment on what Student 12 just said"; however, the student's response is not correct, which frustrated Jack. In this sense, it seems Jack's early attempts at using discourse moves are to elicit correct answers and not necessarily student thinking.

Discourse Practices

Jack often resorts to an Initiate-Respond-Evaluate (IRE) discourse pattern that allows him to lead students through a procedure. Jack positions himself as the knowledgeable authority in the classroom and it was common for Jack to verify responses, both computational and non-computational (see Line 91, 112, 116). In Episode I, none of the students provided Jack with the correct answer as to whether 6/5ths is a rational number (Line 107, 109) and he became frustrated and told them the answer. However, it was more common for the class to provide multiple answers, of which Jack would take up the correct answer. This type of exchange is shown below in the brief exchange that occurred earlier in the same lesson as Episode I.

32	*Jack:*	'Cause 12 over 4 can be represented as what?
33	*S:*	6
34	*S:*	A whole number.
35	*S:*	3
36	*Jack:*	THREE. An integer!

This IRE discourse pattern is typical of U.S. mathematics teachers and was familiar to Jack. He noted in his Methods I reflection that he and his peers "went to school in a time where mathematics classes were mostly lecture based" (p. 1). Jack had previously not experienced a mathematics classroom where student input was central to the discourse. In fact, the notion of discourse in the mathematics classroom was new to Jack, which he described in the following quote:

> When I first heard that we would be having "discussions" in the mathematical classroom I was very confused. I never really thought that students would be able to learn by just talking about math. I have learned that no two students really understand mathematics in the same way. In your class I really found that I was making connections that I wouldn't have made unless I talked with others.
>
> (Methods I Reflection, June 2014, p. 3)

It is clear that Jack's notion of classroom discourse and what was possible in the mathematics classroom shifted early in the program.

In the same course reflection document, Jack identified a role-playing vignette activity as particularly helpful in regards to discourse (see Role Playing in Chapter 4 for a description). Jack's group was assigned Standard for Mathematical Practice Six (Attend to Precision) and was assigned a middle school vignette depicting a teacher facilitating a whole class conversation, where students' definition of a kite is refined through the use of counterexamples (Koestler, Felton, Bieda & Otten, 2013, p. 81-84). Jack found this and the other skits "engaging", but more specifically he noted that these vignettes provided him a strong image "of how to integrate the Common Core" standards and practices into

his classroom (p. 1). Thus, Jack's experience in Methods I provided him a new image of what was possible in a mathematics classroom.

It is evident by Jack's use of the various discourse moves and the question types in his September audio that he attempted to incorporate productive discourse in his classroom. However, Jack was extremely critical of his early teaching practice and was particularly hard on himself in the written analyses. Jack harshly reflected on the audio that Episode I was taken from stating, "when looking back it was a disaster" (Audio 1 Reflection, p. 3). As we move on to Episode II we will see Jack's transition toward a more facilitative role in the classroom discourse allowing students to share their thinking.

Episode II

The excerpt below comes from the March video submitted by Jack for the ALT program final performance-based assessment. This 20-minute video includes two segments of Jack's lesson on Robert Wadlow—the tallest man in the world. Jack asked his students to predict Robert's height given his shoe size. Students were then asked to measure their own heights and shoe sizes and to create a class table. A similar lesson and context was used by one of Jack's peers for the peer-teaching lesson during the summer Methods I course. This original lesson idea stemmed from a *Mathematics Teaching in the Middle School* article about modeling (Imm & Lorber, 2013). The mathematical goal of Jack's lesson was to have students further their understanding of linear equations and to try to make a prediction (i.e., extrapolation, although this word is not used).

The excerpt below comes from the second clip. It begins with Jack pulling the whole class back together for a discussion after students have had several minutes to work with their peers. Jack calls on Student 17, who is a female student he had recently

spoken with individually. Student 17 is Latina and English is her second language. She can be seen in the video using various hand gestures to express herself, which are noted in brackets. Jack allows her to explain her thinking and encourages other students to join the conversation. In this excerpt Jack is facilitating the discussion, and he is not talking as much as he did in the first clip. In fact, we see an instance of student-to-student communication without Jack intervening.

64	*Jack:*	Hold on, I think people are starting to get it now [class quiets down as they raise their hands to match his]. I was talking with a bunch of groups and I think the reason why we are doing the lesson like this, is I really want you to understand what's happening in a function-- what's happening in a linear function. We are saying that this is the y change [pointed to 1.44 on board] and this is the x change. So Student 17 I saw- I spoke with you do you think you can explain it to everybody else?
65	*S 17:*	Yeah.
66	*Jack:*	Okay, go ahead the floor is yours.
67	*S17:*	So like for every inch of his feet grows he grows the [gesturing with hands up and down] the height 1. Well you know pretend he has 5, he is a size 5 so then he grows 1 inch I mean more feet [gesturing length of shoe or horizontally].
68	*Jack:*	One shoe size.
69	*S17:*	Yeah, one shoe size. And then he grows 1.44 um taller [gestures up and down again].
70	*Jack:*	Does anybody have any questions about that or want to ask her a question? I think I understood what she was saying because I talked to her, but does anybody have a question or want to ask a question about what's going on, Student 18? Go ahead.
71	*S18:*	1.4 what?
72	*S17:*	Inches [gestures up].
73	*S18:*	Don't you mean a foot, 1.4.
74	*S17:*	I don't know [mumbles and looks back at board]
75	*S*	[student commotion]
76	*Jack:*	Hold on hold on, let's let her talk for a second if you want to. If you want somebody else to talk just raise your hand and I will call on you, Student 13 do you have a question or a comment?
77	*S13:*	No a question, like how did you get 1.4?
78	*S:*	It's up there on the board [several students are pointing to the board] [students giggle]
79	*Jack:*	So what she's saying [laughing] no, no, that's okay. She's saying that this is changing by 1.44 and this is changing by 1. Student 2 did you

		want to add something to it, do you understand what she is saying? Can you maybe explain it to the class in a different way?
80	*S2:*	Uh, so it means like…
81	*Jack:*	Hold on, hold on. Student 13, just a second. Student 2, go ahead nice and loud please.
82	*S2:*	Same thing that she said. Every shoe size he grows or there is adding 1.44 to his height so, yeah that's it.
83	*S17:*	I think it's inches.
84	*S:*	[student commotion]
85	*Jack:*	Go ahead Student 1.
86	*S1:*	I disagree with her that she grows inches because isn't the 1 feet and the 44 inches
87	*Jack:*	Now the 144 is representing which variable, 1.44 is____?
88	*S:*	y.
89	*Jack:*	Representing y. What is y represent?
90	*S:*	Height.
91	*Jack:*	Height. In _____?
92	*S:*	Inches.
93	*S:*	Ohhhh.
		(Episode taken from Audio 3, 3:01-5:35)

Consistencies in Question Types and Discourse moves

We see several similarities between Episode I and Episode II in terms of questions types and discourse moves used. Jack's most prominent question type in each recording is gathering information (see Appendix O). We see this question type briefly at the end of Episode II (Line 87, 89, 91) when Jack asks several fill-in-the-blank questions. This leading technique was common for Jack and can be seen in several of the data sources. In fact, he observed this pattern during his November audio analysis reflection and noted that, "I really take the lead in helping the students answer the question" (Audio Analysis 3).

Jack continued to use probing questions, which we see again in Episode II (e.g., Line 64). Jack was fairly consistent in the amount of probing questions he asked across each of the data sources. Jack also continued to encourage further student participation (e.g., Line 89). More specifically, he is using the same prompt, asking students if they

want to "add on" to another student's comment to encourage participation (e.g., Line 79).

This particular phrase can be found in each of the data sources taken from Jack's field-placement.

Jack also continues to use various forms of the revoicing discourse move. In Line 79 we see Jack restate a student comment more succinctly to summarize a major point he is trying to make about slope. We also see him use exact repetition of the word "Height" (Line 91) to acknowledge its correctness. Revoicing was Jack's most prominent discourse move across each of the data sources.

Changes in Eliciting and Using Student Thinking

While not evident in the brief excerpt of Episode II, one of the changes in the way Jack used student thinking was his use of counterexamples. In the excerpt below, taken from the November audio, we see Jack field a student question and recognize that the student is highlighting an issue that has the potential to lead to a common mistake. Jack responds by creating an example on the spot that gets at the issue the student is referencing. Unlike the example in Episode I where he leads students through his counterexample (six-fifths), here he poses this example to the rest of the class, and asks them to work through the example.

303	*S 12:*	So if you got let's say you got 11 tens right, the same problem but 11 10's so that would be um 21 with 10 zeros instead of 11
304	*Jack:*	Right, in that situation. It would turn out to that in-the easiest way to do this if you want to work-if, if-don't always think about. Remember how you said in that situation if it's 10 to the 11 power there would be 10 zeros?
305	*S 12:*	Yeah.
306	*Jack:*	It's not always like that. 2.38 times 10 to the 8$^{\text{th}}$ [student chatter] Now how many zeros would there be, work on your own, what would the number turn out to be? [Audio 3, Lines 303-306]

Assessing student thinking and then thinking of questions to redirect ideas on the spot is not an easy task even for an experienced teacher. In the early data sources, we witness Jack identifying student errors without asking students to share how or why they made their errors. This makes it difficult for Jack to build on their thinking. However, in the latter data sources we see Jack allow the students to do more of the talking and explaining, which helps him get a better sense of their thinking. In Jack's reflection for this audio he states, "I think the most important thing to do is constantly have the students explain what they are thinking and on the spot think of questions to try to have them see where their mistake is" (Audio 3 Reflection, p. 3). This shows a notable change in Jack's approach. Instead of using fill-in-the-blank questions to push students to see their answer was wrong, Jack was able to pose an additional problem that he allowed students to work through individually.

Changes in Question Types

During our first interview in February, Jack mentioned that an article we read in Methods I entitled "Questioning our Patterns of Questions" (Herbel-Eisenmann & Breyfogle, 2005) had influenced his questioning practice. In this article, the authors provided examples of a traditional Initiate-Respond-Evaluate classroom exchange and explored the notion of questions that funneled versus questions that focused student thinking. Jack noted in his annotated bibliography that this article provided him with "clear examples of different types of questions" (June 2014). Jack recalled that this particular article forced him to reflect on his previous tutoring experience and the types of questions he posed to students in that setting. Jack stated:

I was giving the kids step by step ways to go through the problems when I was

tutoring which was able to get them, you know, maybe to get through the

assignment or whatever but I wasn't really teaching them *why it was happening or*

how it was happening or anything like that and it was more or less just this is how

you do it, just remember that this is how you do and that's it. (Interview I, Lines

295-300, emphasis added)

When we look at the frequency of the types of questions posed relative to total

question posed each lesson we see an increase in questions that make the mathematics

visible (from 7% to 21%). Later in the discussion from Episode II, Jack asked students

what would happen if they plugged in 0 for x (e.g., y-intercept) and what that would

mean. There were no examples in Episode I or the rest of the audio recording where Jack

posed questions that asked students to explore mathematical relationships, link, or apply

the mathematics. I find the absence of this question type in the September audio

interesting, but not surprising. I hypothesize that the cognitive demand level of the task in

the September lesson (i.e., memorization) impacts this particular question type.

Changes in Discourse Moves

Perhaps the biggest difference between Episode I and Episode II is Jack's role in

the classroom discourse. Instead of dominating the conversation we see Jack take on the

facilitator role as he provides more ownership of the conversation to the students. For

example, he gives "the floor" to Student 17 (Line 66). Jack then attends to the classroom

norms around discourse. For example, he brings the class back to attention when students

start to talk out of turn (Line 76). We see him use a similar move for Student 2, when

Student 13 starts to talk out of turn (Line 81). Providing a safe space for students to share

their thinking and monitoring the classroom norms are indicators that Jack is facilitating, not leading, the discussion. In Episode II he sends a message that he values the students thinking.

This transition was also evident in late November. In the brief exchange below, we see Jack ask a student to restate their explanation, which again allows him to establish the norms for what is appropriate when other students share their thinking.

334	*Jack:*	Everybody listen to Student 4
335	*S4:*	What I did was...
336	*Jack:*	...Hold on Student 4, I've got people talkin
337	*S 4:*	What I did is we do times 10 to equal 23.8 then I did it again, and got equals to 238 and then I put 6 zeros because that's all that's left.
338	*Jack:*	Does everybody understand what Student 4 is saying?
339	*S:*	Yes.
340	*S:*	No.
341	*S:*	Kinda.
342	*Jack:*	Somebody [pause] say it one more time Student 4.
343	*S4:*	When we times it by 10 ones it's going to be 23.8 but when you do it again it's going to be 238 but then you have 6 left over so you put that as zeros so you have 2 hundred and you have 6 more zeros.
		Audio 3, Lines 334-343

Similarly, in the December video Jack stops himself from revoicing a student comment and instead asks the student to explain: "now uh one thing that, Student 31 said that I really want to point out [pause] Student 31 explained [pause] actually Student 31 can you show your explanation of that" (Line 177). The examples evidenced in these three clips taken from November, December and March show that Jack is making a conscious effort to give more ownership to the students and to let the students do more of the explaining.

Changes in Discourse Practices

Jack's notion of how to support mathematical discourse evolved throughout the program. In Jack's annotated bibliography from Methods I, he noted that the articles that

focused on classroom discourse "really help" (p. 14). The articles and activities in the Methods course provided Jack with a new vision of the types of discourse that were possible in a mathematics classroom. For example, Jack observed a link between student engagement and classroom discourse. He mentioned in his Methods II reflection that while working on his undergraduate degree that he "hated to go to class" (p. 1). He felt everything discussed was "in a textbook" and that he "could just as easily learn it on my own" (p. 1). However, Jack felt that he became "hooked" in Methods II and he realized how one could use challenging mathematics "in order to create discourse" (p.1). Given Jack's experience with mathematics in the methods course, he felt it was important to create a similar experience for his middle school students to get them "interested about mathematics" (p. 1). Thus, Jack's beliefs about mathematics and what it means to participate in a mathematics classroom are changing. The articles and mathematical tasks from the methods courses gave Jack a new vision of what a mathematics class could be.

Jack's Ideal Classroom Discourse

In this section I share features of what discourse would look like in Jack's ideal classroom and obstacles that prevent him from achieving this in his current classroom practice. During the final interview, which took place in May, Jack was asked about his role in posing questions and as well as his role in the larger classroom discourse.

Jack was provided the continuum in Figure 6 and asked to locate both his current classroom and his ideal classroom. Jack's placement of his current classroom versus his ideal classroom reveals a large gap (see Figure 6). While Jack did not identify what prevented the student-to-student talk, he did make several comments regarding his own questioning practice.

Jack noted that questioning was an area where he felt he had grown. He stated, "initially I just wasn't any good at it [posing questions] cause I didn't know what to ask" (Line 902). At this point Jack referred back to his struggle on the first audio recording we did during June in Methods I. By May, however, Jack felt that he had improved his questioning stating, "I think I'm getting better at it, it's just one of those things that I need to prepare better and just get better at doing it" (Interview II, Line 911-913). Jack mentioned that the evaluations conducted by his administrators also noted growth and that by the end of the year he was scoring at the "distinguished" level in terms of questioning.
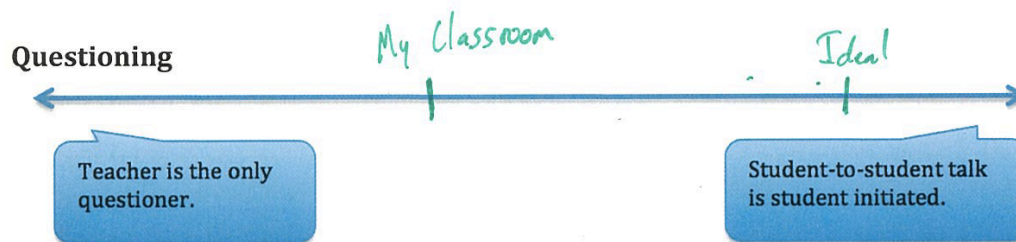
Figure 5. Jack's Ideal and Current Role in Questioning

Jack was also asked about his role in classroom discourse. Similar to my findings, Jack did not perceive himself as dominating the classroom discourse at the end of the year; however, he felt his current practice fell short of his ideal classroom. Jack identified two obstacles that prevented him from realizing his ideal classroom-- "planning and time" (Line 859). As a graduate student, Jack felt he was constantly "crunched for time" (Line 860). He noted that, "you can't just come into a lesson and expect that [productive discourse] to happen" because it required planning (Line 868). More specifically, Jack commented:

It is really hard to think of questions on the spot without leading the student to the answer. I think it is very important to think of possible questions that students have when writing lesson plans. I think that having a plan before class will really help me respond to students thinking. (Methods I Course Reflection, p. 3)

Jack mentioned that when he did not have enough time to prepare questions for a lesson that he did not "feel comfortable" facilitating a discussion (Line 861). The importance of planning in order to facilitating productive discourse was a reoccurring theme with Jack over the course of the program. During our final interview Jack expressed excitement for the following school year when he would "actually HAVE time" to plan and explore curriculum materials.
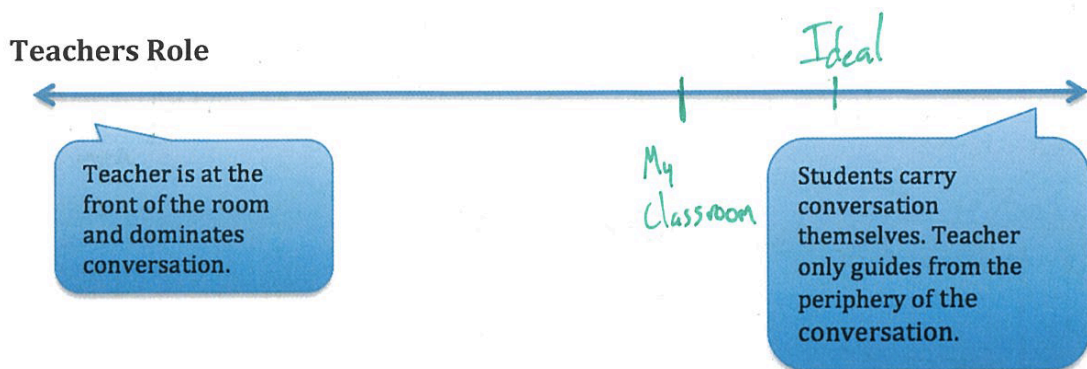
Figure 6. Jack's Ideal and Current Role in Discourse

Conclusion

The two larger episodes used in the chapter provide the reader with a sense of Jack's overall classroom discourse practices and the shift that occurred. He used similar question types and moves in both episodes; however, Jack's role shifted toward a facilitator who supports students sharing their thinking. In Episode I, there is evidence of Jack experimenting with discourse moves and question types that had the potential to

elicit student thinking. However, Jack's frustration with students' incorrect answers resulted in Jack taking control of the conversation and telling students the correct answer. Episode II showed a change in Jack's facilitation of the discourse. Jack decreased the instances of his rapid-fire fill-in-the-blank questions that funneled students toward his way of thinking and instead allowed for more student contributions and thinking to be shared. Jack emphasized the discourse norms and provided an encouraging environment for the students.

Overall, Jack was a successful student in the preparation program. Jack did well in the both Methods courses and scored extremely well on the final program performance-based assessment. Jack's administrators were also pleased with his progress and offered him a full-time teaching position at Hillside Middle for the next school year. Jack was happy about this job opportunity but he was even more excited to hear the specific details. Jack was assigned to the same eighth-grade team with a member from his ALT cohort and they would be teaching the same course next year. When I last spoke with Jack in May, he was enthusiastically talking about plans for next year.

Chapter 6: Jill's Shift Toward Refinement

In this chapter I present the reader with the case of Jill and her developing role as a facilitator of classroom discourse. Jill did not experience a significant shift in her discourse practices. In fact, from the first video recording during June, Jill was using many of the discourse moves, especially revoicing. However, there were minor refinements in Jill's discourse practices, such as the tone used when revoicing or posing a question regarding an incorrect student idea.

I provide the reader with only one episode from Jill's practice since her shifts in discourse practices are minor. I use this episode to highlight the discourse patterns, discourse moves and question types consistently employed by Jill throughout the program. I will then use some of Jill's reflections to point to the minor changes that Jill experienced over the course of the preparation program. To remind the reader, below is a chart summarizing the audio and video data sources. Before I take the reader into Jill's classroom, I first provide an introduction to Jill.

Table 10

Summary of Jill's Audio and Video Data Sources

Type of Recording-Context	Length of Recording (minutes)	Month Recorded	Key Mathematical Idea
Audio- Peer Role Play	5	Early June 2014	Fraction Addition
Video- Peer Lesson	38	Late June 2014	Surface Area of Spheres
Audio- Field Placement	12	Mid-September 2014	Word Problem- Wages and Tips
Audio- Field Placement	53	Late October 2014 (Observed by admin)	Group Lessons Study-Tax and Tip
Video- Field Placement	12	Early December 2014	Dividing by 0
Video- Field Placement	18	March 2015	Circumference and Area of Sector

A Brief Introduction to Jill

Jill is a health conscious, single female, in her early thirties. She earned a B.A. in Business Management in 2005 and a M.A. in Psychology in 2009 from a small private liberal arts college located in the mid-Atlantic region. She was also employed at this same institution for over three years working as a technical consultant. This position allowed Jill to facilitate some training sessions to her co-workers as well as undergraduates. Her most recent employment, prior to entering the ALT program, was for a government agency doing computer work. At the completion of Methods I Jill noted that she had "made the right decision to become a teacher" (Methods I Course Reflection, p. 3).

Jill is a hardworking, talkative, overachieving, driven person. She completed all of the coursework on time, if not early, and was present and prepared for every methods class session. She frequently posed questions during the methods courses, and almost always volunteered comments when teacher candidate input was requested. Jill is an extremely organized individual and she noted in her Methods I reflection that organization was going to be one of her strengths as teacher. While her Type A personality initially irritated some of her peers, by the second methods course they recognized Jill's organizational skills as an asset. She became an advocate for the cohort at the program level, ensuring due dates and workloads were feasible, and that her peers had proper support.

While Jill had a lot to offer in terms of organization and work ethic, she did not position herself as a confident mathematician. During the summer methods course she completed optional readings in an optional text (i.e., Van de Walle, Bay-Williams, Lovin,

& Karp, 2014) to ensure that she was comfortable with the content. Jill was willing to work through mathematical tasks to try to make sense of them. She had no shame with being incorrect and was willing to listen to both her peers' and her students' ideas. In fact, during Interview I, Jill shared that she had recently given an incorrect definition in her classroom and had no hesitation in saying, "guys I was wrong, Student 14 was right" (Interview I, Line 95-6). By the completion of the summer Method course Jill had recognized how humbling the profession was and mentioned she was looking forward to the "constant growth and personal reflection that occurs on a daily basis" (Methods I Course Reflection, p. 3). It was clear that Jill respected her new career and truly viewed teaching as a profession.

School and Classroom Contexts

Jill taught at Hillside Middle School, the same school as Jack. Hillside Middle school is located within a large suburban district and serves approximately 850 students in grades 6-8 (www.nces.ed.gov 2013-2014 school year). Hillside Middle School is a Title I school and served a predominately Hispanic community. Approximately 67% of the students were Hispanic, 28% were Black, 3% were Asian/Pacific Islander, and about 1% were white. Approximately 78% of the students were eligible for free lunch and about 11% were eligible for reduced-price lunch. Hillside Middle School is part of a district technology initiative and each student is provided with an iPad. Like Jack, Jill was also enrolled in the ALT program and was the teacher-of-record for half of the school day. Jill was assigned the highest performing seventh-grade students who were labeled as "honors" and she met with them daily for 65 minutes.

Representative Episode

The episode below was taken from a 12-minute video recorded during Jill's field placement in early December. Jill identified two Standards for Mathematical Practice that she was emphasizing in this lesson: SMP 3 and 5 (i.e., Construct viable arguments and critique the reasoning of others; and Use appropriate tools strategically). In this lesson, Jill had students use manipulatives to explore integer division (i.e., CCSSM 7.NS. A. 2b). Jill asked students to take their 12 tiles and create 12 groups, then 6, 4, 3, 2, and 1 group. At each of these increments students were asked how many tiles there were per group. For example, students took their 12 tiles and divided them into 6 groups and then identified that there would be 2 tiles per group (i.e., 12/6=2). Jill then asked students what would happen if there were 0 groups.

This episode was chosen because it is representative of Jill's overall teaching and it shows the way that Jill allows student thinking to move the conversation forward. Relative to her peers, this episode was strong in terms of classroom discourse. However, Jill noted during the first interview that she recalls the discourse during her second block (not video recorded) for the same lesson "was better" (Interview I, Line 472) because she was "better prepared for the questions that they were going to ask" (Interview I, Line 481-2).

This episode provides examples of Jill's use of a variety of discourse moves and questions types. For example, Jill asks Student 20 to go to the board to show their work and then invites Student 7. We can also see Jill continuing to develop and reinforce classroom norms around discussions. Jill uses gathering information questions as well as probing questions that ask students to share their thinking. This episode also offers a

variety of discourse moves such as the following: revoicing, asking a student to repeat another student's idea, asking a student why they disagree with another student's reasoning, and prompting another student to join the conversation. The excerpt below takes place during the later half of the recording and captures the whole class discussion that followed group work time regarding division by 0.

61	*Jill*	So who wants to volunteer an answer [a few hands go up]? What do you think Student 19?
62	*S19:*	Uh… [student talking]
63	*Jill:*	Guys I need everyone to listen.
64	*S19:*	[Inaudible]
65	*Jill*	So who thinks 12 divide by 0 is 0? Raise your hand [at least 3 hands go up].
66	*S7:*	I disagree.
67	*Jill:*	Student 7, why do you disagree?
68	*S7:*	Because you can't divide 12 by 0 or any number 0 because [interrupted by another inaudible student comment] BUT it's not zero.
69	*Jill*	Student 20, student 7 just made a point that you can't divide any number by zero, do you agree with her?
70	*S20:*	[no verbal response heard]
71	*Jill*	Why do you agree with her?
72	*S20:*	Because when you multiply zero by zero you get zero and when you multiply another number by 0 you still get 0.
73	*Jill*	[Jill makes gesture of handing chalk] Show that up on the board.
74	*S20:*	[student walking to get chalk]
75	*Jill*	So a lot of you said that if we were to do 0 groups we would get 0. I need you guys to pay attention and see if you agree or disagree with Student 20.
76	*S20:*	[standing at board] Do that? [pointing to screen referring to filling in the last two blanks]

Number of Groups	Tiles per Group	Math Equation
12	1	12/12=1
6	2	12/6=2
4	3	12/4=3
3	4	12/4=4
2	6	12/2=6
1	12	12/1=12
0		

| 77 | *Jill* | Just, put up what you explained |

78	*S20:*	[writing on board 0x0=0, 0x12=0]
79	*Jill*	Okay, so why can't I divide by zero?
80	*S20:*	[inaudible]
81	*S*	[other students start chatting]
82	*Jill*	[points another student to the board] Go.
83	*S*	[students chatting]
84	*S7:*	[writing on the board out of view of camera] Okay so that means if you do 0 times 0 you're not going to get 12, when going to get 0 so you can't divide [inaudible]
85	*Jill*	So Student 21, what do you think of what Student 7 just said? Student 8 I need you to focus honey.
86	*S8:*	Huh?
87	*Jill*	I need you to focus. Student 21, what do you think of what Student 7 just said?
88	*S21:*	I think it's true.
89	*Jill*	Why?
90	*S21:*	When you um, you can't get [inaudible]
91	*Jill*	So who was able to make 0 groups with their blocks?
92	*S*	[no response]
93	*Jill*	Everybody take your 12 blocks, who can make zero groups with them?
94	*S1:*	[hand goes up] I did.
95	*Jill:*	Yes, go ahead Student 1.
96	*S1:*	I ...
97	*Jill:*	guys I can't hear Student 1 and she's two feet away from me [pause] hold on a second Student 1 your classmates are being rude [pause] go ahead
98	*S1:*	[inaudible speaking too softly]
99	*Jill:*	[C2 noticed Student 8 inattention] Student 8, can you repeat what Student 1 just said to me?
100	*S8:*	I can't hear, because I wasn't paying attention. To be honest I wasn't paying attention [other students laughing] I heard nothing but blablablabla
101	*Jill:*	Student 8, can you try very hard for me to pay attention? [Jill does not appear mad at this comment and even smiles] (Episode taken from Video 2, 6:36-10:06)

Elicit and Use Evidence of Student Thinking

As previously mentioned, this episode shows the way that Jill used student

thinking to move the conversation forward. As evidenced in the transcript, she invited

two students to the board to explain their reasoning to the class. This was an intentional

and common discourse move made by Jill. Jill noted in her Methods II reflection,

I know how to have a discussion with my peers, but creating productive discourse among 12-year-olds is really hard. I found it helpful to get ideas on how to create productive discourse by using the students' ideas. (Methods II Course Reflection, p. 3)

Unlike her peers, Jill often explored students' incorrect ideas or thinking that could potentially lead the conversation astray. Jack rarely explored wrong ideas, and often ignored wrong answers completely. In this episode we see Jill start to explore a student who has a wrong idea (i.e., making 0 groups) (Line 95); however, the moment is interrupted when Jill addresses a behavior issue with another student. Eliciting student thinking around misconceptions was typical in Jill's classroom. Instead of evaluating or telling the student the correct answer Jill would often pose the idea to the class. For example, during the March video Jill revoiced an incorrect student idea, "So the formula for circumference and area is the same" (Video 3, Line 121). She followed up with a question posed to the whole class for discussion, "What do you think about what Student X just said?" (Video 3, Line 123). These are just a handful of the examples that show that Jill utilized student thinking to facilitate the class discussion.

Question Types

This episode shows Jill using questions to both gather information as well as to probe students' thinking. Both of these questions types were prominent in all of Jill's recordings (see Appendix Q for Question Types by recording). One aspect lost in the condensed coding scheme was the variety of gathering information questions used by the teacher candidates. Recall that in the condensed coding scheme, recall questions, asking students to insert terminology, orienting and focusing student thinking, or asking

questions that establish context, were all assigned the same code. While not represented in this particular Episode, Jill was the most frequent user of questions that established context. For example, it was common for Jill to use real-world scenarios in her classroom. When she did, she often posed questions to help students understand the context (e.g., What is gratuity? Could we have tips in other services, or other industries besides wait staff?). According to Jill, the mathematical task of the episode in the transcript above was asking students to practice "procedures with connections" and she did not link this to another context.

Early in the program Jill realized that posing purposeful questions was not a simple task. In fact, during her first video recorded lesson during which she taught her peers, she really stumbled when posing questions. For example, when Jill launched the activity that would allow students to explore the big idea of the lesson (e.g., surface area of a sphere) she struggled to pose the question. Jill said the following: "How much of the peel is going to fit inside the circle, or not how much of the peel, how many circles do we need for the peel to fill [pause] that's still not making sense" (Video 1, Line 80). In her reflection she noted, "I misspoke a number times" and "I feel I confused the students" (Video 1 Reflection). At the completion of Methods I Jill identified "question prep" as area in which she needed to improve (p. 3).

Jill recognized that thinking through questions during lesson planning was important, but that it required more planning time. Recognizing the challenge in creating questions that elicit higher-level thinking, Jill turned to available resources in the field. In her reflection for Methods II she noted that she had recently used the suggested questions from a MARS lesson on increasing and decreasing quantities by a percent. Similarly,

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during her second Interview she again mentioned using the MARS activities "because they have really good questions." Additionally, Jill used an NCTM illuminations activity and noted that it had "some really good questions for discussion" (Interview II, Line 236-237). Of the three case study candidates, Jill was the one who relied most heavily on resources from the field to help her pose purposeful questions.

Discourse Moves

Jill was an avid user of discourse moves from the beginning of the program. In the above transcript Jill revoiced student ideas (Line 69), asked a student to repeat another students idea (Line 99), asked a student why they disagreed with another student's reasoning (Line 67, 87), and prompted another student to join the conversation (Line 82). Jill was a perhaps too extreme on the amount of revoicing that she used in her classroom. Jill revoiced almost every student utterance made in her classroom. Unlike Jack, when she revoiced she most frequently restated the student idea almost verbatim and provided ownership to the student. This can be seen in the episode above in Line 69. During the first interview she noted the mid-September audio analysis allowed her to notice this pattern. Jill stated, "I will over repeat things so then students get in the habit of not listening the first time" (Interview I, Line 393-4). While this was noted early on, Jill continued to repeat things frequently.

The mathematics education literature warns against too much revoicing (Cirillo, Steele, Otten, Herbel-Eisenmann, McAneny, & Riser, 2014) noting, similarly to Jill's comment, that "there is little reason for students to listen to one another's contributions, and this may affect the ownership of ideas" (p. 147). Interestingly, I found student utterance from Jill's classroom difficult to transcribe and at times inaudible (e.g., Line 64,

90, 90), so it was essential that Jill revoiced these comments for me to follow the conversation. However, it is not clear whether her revoicing allowed students to speak too softly, or whether some of the vocal students were simply shy. Since Jill provided ownership to the student through her revoicing, it did not seem to impact the participation level of her students.

While revoicing was Jill's primary discourse move across all data sources, she also frequently prompted for further participation from her students. A common phrase for Jill to use was to ask, "Do you have something to add?" She also frequently stated a student name if they raised their hand, as a way of acknowledging that they wanted to participate in the conversation. It was common for Jill to use specific student names to facilitate the discussion and to provide ownership to the students. In fact, this was in stark contrast to the subsequent case—Meredith.

Jill also asked students to compare their reasoning to another student's thinking. While this move was not nearly as frequent as the previous two, she used this move at least once in e

audio and video recording. She most often asked if students agreed or disagreed with specific comments. She also would occasionally ask "What do you think about what Student X said?" as she did in Line 87 above.

Discourse Practices

While Jack and Jill were both very talkative people and their voices both dominated classroom talk time, they differed in their substance. Jill positioned herself as a facilitator of the discourse from the beginning of the internship and never the mathematical authority in the classroom. While Jill acknowledged that she was still

refining her role as a facilitator, her goal was to have "student-led discussions" and "students having confidence in their own mathematical ability" in her classroom (p. 5). Jill noted in her March written commentary that these were two key ideas she gleaned from the Arbaugh and Avery (2008) reading in Methods II. Jill specifically stated that she didn't want to be seen as the "authority" in the classroom. Unlike Jack, Jill did not offer many of her own mathematical explanations or summaries in any of the data sources for this research. Jill talked almost as frequently as Jack, but her talk turns are usually revoicing or restating a student contribution. Thus, the ownership of the mathematical ideas was always attributed to the students.

Jill acknowledged that she had "vey high expectations for respect" and that she reinforced appropriate behavior and addressed inappropriate behavior often in her classroom, which occurred in the episode above (Lines 97, 101). She noted that she didn't "put up with" certain behaviors, specifically "talking down to each other" because it was one of her "pet peeves" (Interview I, Line 358-9). These ideas around classroom discourse norms were also evident in Jill's commentary written in March for her ALT program performance-based assessment. Jill cited the following key ideas from a reading from Methods I (Stephan, 2014) stating:

> The article contains six strategies that I have worked to implement in my own classroom: 1) State expectations before the first explanation occurs, 2) Hold students accountable for explaining, 3) Hold students accountable for asking questions, 4) Hold students accountable for making sense of solutions, 5) Hold students accountable to question what they do not understand, and 6) Praise students for their participation and providing informative feedback. (p. 4)

It was quite common for Jill's students to respond to prompts with common sentence starters such as "I agree/disagree with Student X because…". This was noted as early as Jill's first field placement audio recording in mid-September. As the methods instructor who listened to 16 teacher candidate audios, I knew this was not typical for most classes at that point in the school year. When I asked Jill during her first interview about this student discourse she did not take credit for this development. In fact, she claimed, "Some of them [the students] came in using that language" (Line 293). Jill continued to attribute credit to others during the second interview stating: "I think overall the school in general is really good at encouraging students to explain their thinking" (Interview II, Lines 313-5).

When visiting Hillside middle for the interviews I noticed a poster in a science classroom that focused on accountable talk and had sentence starters; however, when I asked Jill she mentioned that this science teacher was not on her grade-level team. While Jill's students may have been familiar with certain classroom discourse practices or norms, this was not prominent in any of the other eight September audios that I listened to from Hillside Middle. Thus, it appears that Jill was doing more to develop productive classroom discourses early in the year than she was giving herself credit for.

Changes in Discourse Moves and Question Types

As mentioned in the introduction, Jill did not encounter any major shifts in her overall classroom discourse patterns over the course of the program. However, there were refinements that made Jill's use of specific discourse moves and/or question types more effective. Below I will describe one of Jill's more notable changes: tone.

In the September audio recording, students were working on an Algebra story problem that appeared in one of our course readings: "When Jon got home from his waiter job, he multiplied his hourly wage by the six hours that he worked that day. Then he added the $66 he made in tips and found that he earned $81.90. How much does Jon make per hour?" (Nathan & Koedinger, 2000, p. 219). Prior to this reading, teacher candidates were given a set of six problems and asked to rank them by level of difficulty. This goal of this article was to address teacher assumptions regarding students' struggles with Algebra. The teachers in this article, as well as the teacher candidates in the methods course, assumed students struggled more with story and word problems; however, test results showed students performed better on story and word problem and in fact struggled more on arithmetic and algebraic equations. Many of the teacher candidates were shocked by these results and Jill decided she wanted to try one of Algebra story problems that she and her peers perceived as difficult in her seventh-grade classroom to see how students approached the problem. Jill noted during the first interview that this particular article had helped her think more deeply about what students might struggle with because what she initially thought "would be difficult wasn't difficult" (Interview I, Line 603).

Jill was the only case study candidate who regularly revoiced or pursued incorrect student ideas. In fact, this was a technique that Jill used throughout the data sources. Below is a brief excerpt from an early audio recording that shows Jill questioning and encouraging Student 2, who took an incorrect first step, to share her work.

13	*Jill:*	Did anyone else have a different step?
14	*S2:*	[silence]
15	*Jill:*	Yes, Student 2. What did you do for a first step?
16	*S2:*	I divided.
17	*Jill:*	You divided! What did you divide?
18	*S2:*	6 hours divide 81 dollars and 90 cents

19	*Jill:*	Can you write that up on the board for me?
20	*S2:*	[silently writes on the board]
21	*Jill:*	And then can you just write your answer above.
22	*S2:*	[silently writes on the board]
23	*Jill:*	Okay, so Student 2 divided 81.90 by 6 and found 13.65. Did someone do something different? Yes Student 4, What did you do?

(Excerpt taken from September Audio 2:25-3:15)

During Jill's analysis for this audio she noted her surprised reaction to Line 17 and stated, "I need to keep that kind of emotion out of my voice so that students can't figure out the correct answer by my tone." In a similar fashion, when another student provided an incorrect solution Jill asked if someone could "help her out" (Line 35). This was not the only example in this audio where Jill noted her tone or phrasing "could have been harsh" or "gave away" her reaction or confusion to a student comment.

The teacher's use of inflection has been noted to impact classroom discourse, especially in terms of revoicing (see Krusi, 2009). While this research was not directly addressed during the methods course, Jill received several suggestions in feedback from the instructor on this assignment. Reflecting on this audio seemed to be a turning point for Jill and from this point forward there was a shift in the way that Jill responded to incorrect student ideas. One could no longer tell whether she thought the student was correct or incorrect by her tone or the inflection in her voice.

Jill's Ideal Classroom Discourse

In this section I share features of Jill's ideal classroom discourse and obstacles that prevented her from achieving this in her current practice. During the final interview, which took place in May, Jill was asked to address her role in questioning and her role in

the larger classroom discourse. For each of these prompts Jill identified where she felt her current classroom practice fell as well as her ideal classroom on a continuum.

Jill's placement of her ideal classroom questioning practice shows that she would like a classroom that contains student-to-student interactions. Jill noted that she felt her "students seem to ask really good questions" and that they often challenged her to provide the "why" behind a lesson. However, Jill did not comment on why she thought the students did not have more peer interactions.
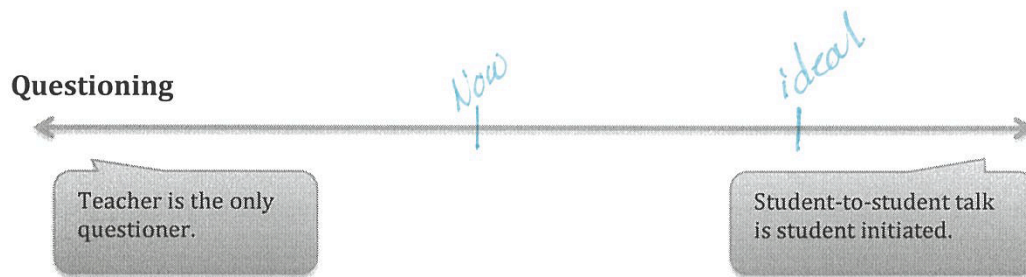
Figure 7. Jill's Ideal and Current Role in Questioning

In terms of the teacher's role in the discourse, Jill identifies her current practice much farther to the left than the data provided evidence. Jill justified her placement with the following comment:

> I feel like I'm more on this side of the continuum of being in front of the classroom because that is how I was taught, that's my background that's where I'm coming from um and frankly sometimes it's just easier like if you don't have a lot of time to really put in like really in-depth planning being at the front delivering information is easier. (Interview II, Lines 269-277)

Here we see Jill acknowledge planning as one of the challenges in facilitating productive

discourse. This tension regarding the amount of time to create a thorough lesson plan

came up several times for Jill. In the Methods II end of course reflection, Jill stated,

> I feel a key component of creating productive discourse is based in the work done
>
> before the lesson with anticipating, and then with monitoring students while
>
> they're working so that you are using their ideas within the course of the
>
> discussion. (Methods II Reflection, p. 3)

Jill felt that with practice she could improve classroom discourse. Jill had a vision for

what she wanted to accomplish and it was "within reach" (p. 3). Perhaps this is why Jill

turned to the field for resources and lesson plans.

Figure 8. Jill's Ideal and Current Role in Discourse

Conclusion

Jill received high marks in both the methods courses as well as the ALT program

final practice-based assessment. The data in this research show that Jill continued to

refine her discourse practices over the course of the program. Jill ability to be critical and

reflect on her own practice allowed her to make small improvements. For example, Jill

noticed her evaluative tone when revoicing incorrect answers and was able to eliminate it.

These small changes assisted Jill in refining her role as a facilitator of classroom

discourse. It was evident that Jill viewed teaching as a profession that required constant reflection and refinement. Like Jack, Jill also impressed her administrators and was offered a full time position at Hillside Middle School for the 2015-16 school year. Jill accepted this offer and was also asked to continue to teach seventh-grade. Unsurprisingly, Jill reached out for additional curriculum materials at the start of the new school year.

Chapter 7: Meredith's Shift Between Discourse Practices

In this chapter I present the reader with the case of Meredith. Meredith differs greatly from Jack and Jill in many respects, two of which impact this study. First of all, Meredith was in the MA program, which means she was placed in a year-long internship with an experienced mentor. Secondly, unlike Jack and Jill, Meredith was a quieter person who spoke much less frequently and did not like to dominate conversations. These two differences impacted the mathematical discourse in Meredith's classroom.

Meredith had a strong vision for what she wanted her ideal classroom to look and sound like and she was critical of her own practice when it did not meet her standards. Of the three TCs, Meredith expressed the strongest desire for her classroom to be student-led. Meredith showed she was able to bounce between discourse practices over the course of the program. That is, the classroom discourse would shift between discussions driven by student thinking (i.e., Late June, September, December) and teacher-directed procedures (e.g., Early June, October, February). This oscillation between discourses was related to several constraints that Meredith faced in her placement, such as negotiating with her mentor's norms and time constraints. Meredith was extremely critical in her methods course assignment reflections, even though they showed evidence she was facilitating productive classroom discourse.

Two episodes will be used to contrast the differences in the types of discourse that occurred in Meredith's classroom. The first episode, taken from Meredith's September audio recording, shows that Meredith was practicing many of the discourse moves and question types to elicit student thinking. The second example comes from Meredith's performance-based assessment video, which was recorded in late February. These

examples were not chosen to represent change over time. Instead, they were chosen to be representative of the two different types of classroom discourse between which Meredith was able to oscillate. Below is a chart summarizing the audio and video data sources and the context in which they were recorded and the key mathematical idea explored in the recording. Before I take the reader into Meredith's classroom, I first provide an introduction to Meredith and an overview of her school and classroom context.

Table 11
Summary of Meredith's Audio and Video Data Sources

Type of Recording-Context	Length of Recording (minutes)	Month Recorded	Key Mathematical Idea
Audio- Peer Role Play	3	Early June 2014	Fraction Addition
Video- Peer Lesson	30	Late June 2014	Dividing Fractions
Audio- Field Placement	15	September 2014	Fractions on a number line
Audio- Field Placement	59	Late October	Literal Equations
Video- Field Placement	15	Early December	Graphing y= x^2 and y= abs(x)
Video- Field Placement	20	Late February	Solving Systems of Equations

A Brief Introduction to Meredith

Prior to beginning the MA program, Meredith, a female in her early twenties, graduated from a small liberal arts college within the mid-Atlantic region. She majored in Psychology and had minors in both Education and Mathematics and graduated Magna Cum Laude. While in college, Meredith served as an orientation leader and volunteered with the Special Olympics. She also participated in collegiate athletics and served as the team captain during her junior and senior years of competition. Meredith had also been

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an assistant coach for several summer youth teams in the area. These leadership positions show that Meredith was a responsible individual and was seen as a role model. These qualities were also evident in Meredith's coursework in the program. Similar to Jill, Meredith was always on time-early for each class session and she was one of the first to submit each assignment.

Similar to Jack, Meredith was comfortable and confident in her mathematical abilities; however, unlike Jack she did not jump at the opportunity to explain her thinking to others. Meredith was an extremely thoughtful individual and would often listen to others' thinking prior to contributing her own thoughts. If called upon, Meredith was never afraid to share her opinion and she always made thoughtful contributions.

<p style="text-align:center">School and Classroom Contexts</p>

Meredith's field placement was in the same large suburban district as Jack and Jill's; however, the student population and economic status differed greatly. Meredith was at a more affluent, Non-Title I, public middle school. Meredith's placement school, Meade Middle School, has approximately 875 students in grades 6-8 (www.nces.ed.gov 2013-2014 school year data) and served a predominately African American community. Approximately 61% of the students are Black, 16% are White, 11% are Hispanic, less than 7% are Asian/Pacific Islander and 5% identify as two or more races. Approximately 24% of the students were eligible for free lunch (whereas Hillside middle was 78%) and about 5% were eligible for reduced-price lunch.

Meredith was placed with Mary, a veteran teacher of 29 years, who had been assigned eighth grade math for the last several years. Meredith and Mary's schedule consisted of two Math 8 sections and two Algebra classes. All of the data from this study

come from the Algebra class. Mary was an experienced mentor and had worked with the university previously; however, Mary had recently taken on more administrative types duties at Meade, which impacted her role as a mentor. Meredith commented during the fall mid-course check in that "she [Mary] and I don't sit down and plan b/c she always has meetings to get to or things to do administrative-wise" (Methods II mid-course check-in, p. 1).

According to Meredith, Mary was a traditional teacher. Meredith stated, "my mentor merely has the students take notes on what they are learning, then the students are given problems to practice the procedures" (Methods II mid-course reflection, p. 1). This traditional type of teaching aligned with the layout of the classroom. Mary had student desks arranged in three long rows that were contained in the back half of the classroom with teacher desks and materials taking up the other half. The tight rows made it difficult for Meredith to monitor individual student work: she was often only able to observe from the perimeter. During the first interview, Meredith mentioned that she wanted to have groups and that she had attempted to restructure the room once when her university supervisor visited; however, the rows were too tight and it was difficult to "even get to each table" (Interview II, Line 209). At times Meredith was very critical of the traditional structures of Mary's classroom. Meredith confessed the following: "I learned a lot what **not** to do but I'm still concerned that I do not know what **to** do" (Methods II mid-course check-in, p. 1, emphasis in the original). While this style of teaching is not what Meredith envisioned for her own classroom, she recognized that Mary had a lot of expertise to offer. Whereas Meredith struggled making connections between units and "seeing this full year as a whole" (Interview II, 459-60), Meredith felt Mary did "that really well"

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(Interview II, Line 462). Although the placement was not ideal for the type of teaching that Meredith wanted to practice, it provided her with many positive experiences.

Episode I: Discussion Focused Around Student Thinking

This episode was chosen because this was the first data source taken from Meredith's field placement and it shows her experimenting and reflecting on her use of questioning to get at student thinking. In this excerpt, Meredith had students talking and sharing their thinking; however, she was extremely critical of this episode in her reflection. In terms of probing student thinking, Meredith encouraged three different students to share their thinking and she invited several students to participate in the conversation through her questioning. Meredith uses several discourse moves in this episode: revoicing, prompting for further participation, and applying someone else's reasoning. This episode also provides an example of how Meredith handles a student with an incorrect solution.

In this 15-minute audio segment, the students were given six fractions and asked to place them on a pre-drawn number line that was labeled with a 0 and 1. The fractions were as follows: 5/10, 1/3, 1/4, 5/17, 7/11, and 6/13. Meredith invited students to the front of the room and asked them to place a post-it where they thought the number should be and to explain why they thought it went there. It should be noted that there were several inaudible student comments in this clip that were due to the poor quality of the recording. This clip starts with the second student who was invited to the board as he attempts to place 1/3rd on the number line.

27	*Meredith:*	Student 2, do you want to do another one?
28	*S2:*	Sure [Student 2 placing 1/3 on the number line]
29	*Meredith:*	Why?
30	*S2:*	Because when I think about 1/3… [interrupted by Meredith]
31	*Meredith:*	Don't tell me, tell them.
32	*S2:*	Oh, cause when I think about 1/3, um only 1 part is like a whole number section, of everything.
33	*Meredith:*	Okay, so this is one half, so right now you are saying that this part of one half is 1/3 of the whole. [Student non-verbally confirmed revoicing] Okay. Does anyone have any questions for him?
34	*S?:*	I do.
35	*Meredith:*	Okay, why?
36	*S?:*	um [silence] it's uh, 1/3, means that more than or [correcting himself] less than half and um [silence]
37	*Meredith:*	Student 3, do you want to help?
38	*S3:*	Um, on the number line I kinda did 0 to 1 with numbers so like 1 to 10
39	*Meredith:*	Okay. Why did you do that?
40	*S3:*	Um, to make it easier (inaudible) because I knew 1/4 and 1/3 and I knew it would be a little farther than 1/4 [inaudible explanation] cause their all tenths
41	*Meredith:*	So does everyone know what she means by marking each one as a tenth? From 0 to 1 how many ticks are there?
42	*SS:*	10
43	*Meredith:*	10 okay, so each marks 1/10, so you [referring back to Student 2] placed 1/3 at 1/10 right now. Do you want to look at this again and change where you put 1/3? .
44	*S2:*	[moving post-it but no verbal communication]
45	*Meredith:*	Ok. Why?
46	*S2:*	Cause what she said. It's more closer to 1/2 than 0.
47	*Meredith:*	C1: K, does everyone agree?
48	*Many S:*	Yes, Yes.

At this point we see a slight shift in the types of questions used and the direction of the conversation. Meredith stops asking the students for their thinking and she starts asking gathering information type questions that lead the students toward her thinking. None of the students had mentioned using percents as a way to think about this problem, but Meredith provides this as another technique.

49	*Meredith:*	Okay, 1/3 is roughly what percent?
50	*S:*	33
51	*Meredith:*	Okay and then if you were to put, so if this is, how much percent is this? [pointing to the various tick marks on the number line]
52	*Many S:*	10, 20, 30, 40
53	*Meredith:*	Okay we want it to be a little bit more than 30%, alright or 3/10, because it is a little more than 3/10, okay so just like we practice if fractions don't make sense to you at first you can convert them in any way that you want to make more sense to you, okay does someone want to do another one, Student X?

(Episode taken from Audio 2, 6:02.09- 09:04.29)

Elicit and Use Evidence of Student Thinking

In comparison with her peers' September audios, this was strong in terms of eliciting student thinking. Meredith was able to elicit thinking from three students regarding their placement of 1/3 in this brief clip (i.e., S2, S3, S?). However, Meredith was very critical of her teaching and in her reflection identifies areas where she, in fact, did not elicit student thinking. For example, Meredith mentioned in her reflection that her goal was for students to see why it made sense to divide the number line into tenths, so she posed the following question "From 0 to 1 how many ticks are there?" (Line 41). While it appears that Meredith was trying to pose a question to help make the mathematics more visible and for other students to see the connection to the strategy of dividing into tenths, she recognizes that this particular question did not help the students conceptually. According to Meredith she only "learned that these students were able to count" the tick marks (Audio 2 Reflection, p. 4). Similarly, Meredith was not pleased with the question she posed in Line 41 to see if the other students followed Student 3's explanation (e.g., Does everyone know what she means by marking each one as a tenth?). Meredith harshly noted, "I learned nothing, students merely nodded their heads" (Audio 2 Reflection, p. 4). Meredith suggested that she could have improved the discussion if she

had simply "chosen another student to further explain how Student 3 had gotten 1/10 (Audio 2 Reflection, p. 4). It is clear by September that Meredith recognized that both the questions she posed and discourse moves she used directly impacted what she is able to elicit in regards to student thinking.

Question Types

Meredith used a variety of question types in this brief segment and she saw that as an important aspect of questioning. Meredith commented that probing questions where "not always going to be an appropriate question to further the students' understanding" and that she would need other types of questions (Methods I Course Reflection, p. 3). While Meredith had a variety of question types, she again was critical of the questions she posed. For example, in Line 33 Meredith asked the class if they have any questions for the student who had just placed 1/3 incorrectly. For a novice teacher there are several great things about this question. To begin, Meredith did not evaluate the student's comment as Jack did, nor indicate with her tone that he was incorrect as Jill did. Instead, she revoiced what he said to clarify and verify his statement and then posed it to the class. In fact, Meredith's question encouraged another student who disagreed to join the conversation.

So, there are many positive aspects to this particular question she had posed. However, Meredith critiques her question and reported in her reflection, "I was asking the students to ask questions that I myself was unable to find and ask" (Audio 2 Reflection, p. 4). This honest assessment shows that Meredith was not quite sure how to handle the incorrect response. Meredith had noted in her Methods I reflection that she was concerned and felt one of her "weaknesses involve student anticipation, especially in

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creating possible questions ahead of time" (p. 3). It appears this is an instance where she had not anticipated the student would struggle with placing 1/3.

One aspect of this clip that was representative of Meredith's questioning technique was her use of the simple one word probe- "why?" (Lines 29, 35, 45). The brevity of this question aligns with Meredith's pattern to not dominate the discourse and to let the students do more of the talking. However, Meredith recognizes in her reflection that she should be more precise in what she is asking and that she did not need to be so brief. For example, she suggested that she could have simply asked, "Why did you place it exactly here?" (Audio Reflection 2, p. 5) to replace Line 45 and that the question would be clearer for the student.

Probing questions were prominent in Meredith's late June, September, and December data sources (see Appendix R). In Meredith's December video we see her trying to continue to be more precise in her probing questions and moving beyond the simply "why" prompt [e.g., "Why would it be continuous?" (Line 47), "Why would it look like that" (Line 59)]. Meredith does use some probing questions (n = 9) during her October audio, however, when compared to the number of gathering information questions (n = 42) they seem overshadowed.

Meredith noted the change in her questioning strategy that took place around Line 49. She recognized that she posed a leading question (Line 49) and that if she had posed other questions she likely could have had a student who would have been able to share the percent strategy without her having to lead the class toward this strategy. Meredith's reflection on her September audio shows that she recognizes the importance behind posing purposeful questions; however, this was also evident in Meredith's reflection from

June. During her peer-lesson, she had thoughtfully prepared questions ahead of time that focused on the key mathematical idea of the lesson (e.g., Identifying the whole). Meredith noted in her reflection,

> I would have never thought about how important it is to make sure that we have questions previously written down for each lesson. Thinking about student responses ahead of time was a huge help to me when I was making my lesson plan. (June Reflection, p. 2).

This preparation prior to the lesson allowed Meredith to pose thoughtful questions to help her assess some of her peers' struggles and to pose questions to draw attention to the big mathematical ideas.

Discourse Moves

As mentioned above, this clip shows Meredith using three different discourse moves: revoicing, prompting for further participation, and applying someone else's reasoning. While Meredith did not attempt to use revoicing in her late-June video, she used the discourse move five times during the September audio. Meredith's use of revoicing is much less frequent than Jack and Jill and appears to serve a different purpose.

In the episode above there were two examples that differed from Jack and Jill's early attempts at revoicing. Meredith uses revoicing in Line 33 to clarify a student comment and to check back and verify whether she correctly understood the student, which was a move Jill did not use until later in the internship. The student's original comment was somewhat vague and his justification was "only 1 part is like a whole number section of everything", so Meredith rephrases for clarity. It seems as if the

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student was confused on what the whole is in the diagram, and Meredith asked "so right now you are saying that this part of one half is 1/3 of the whole," to which the student seems to provide non-verbal agreement. The student was incorrect in his placement and after checking with the student she posed his idea to the class. This is a particularly strong use of revoicing for a novice teacher. Meredith's second use of revoicing in the episode above was not particularly strong. Instead of restating the student's comment or thinking, Meredith simply reiterated the method (i.e., using tenths). As addressed above, Meredith recognized that this move did not offer her much insight to what the other students were thinking and did not allow for further discourse.

Prompting for further participation was another discourse move Meredith used. This particular move was one of the more prominent discourse moves used by Meredith across all data sources. In the example above (i.e., Line 37) Meredith uses the move when it appeared a student was stuck and allowed another classmate to "help." More often Meredith simply stated a student name to invite them into the conversation. This was typical when Meredith was launching a lesson and trying to get initial student input. For example, during Meredith's December video she began by asking students to predict what a graph of the absolute value looked like. Meredith was careful to never evaluate or critique these initial comments, and she would use this technique to gather several different student ideas. Similar to the Jack (n=8) and Jill (n =11), Meredith would also ask students if they wanted to "add" or "add on" to another student comment to generate further participation. While this is not shown in the episode above, Meredith used these phrase occasionally (i.e., late June Video n = 1; October Audio n = 1, December video n = 2).

While both Jack and Jill would occasionally (n = 7, n = 8 respectfully) ask students if they agreed or disagreed with another student's contribution, we do not see Meredith using this discourse move as frequently or in the same way. There are only three instances where Meredith used this move across all of her data sources, and we see one example in the Episode above (Line 47). However, it is interesting to note that Meredith did not ask for agreement or disagreement, she simply stated "Does everyone agree?", which was less effective. This prompt generated several students to reply "yes" but no further discussion was created.

Discourse Practices

Overall, Meredith was very critical of many aspects of her facilitation of discourse in this clip. She had a very strong desire to have a student-led classroom and she felt she was not there yet. This is relevant when we examine the amount of talk time that Meredith used. Compared with Jack and Jill, Meredith's voice was not the prominent feature in the class discussions. Like Jack and Jill, Meredith alternated talk turns with her students; however, her turns were often shorter. This was apparent when she repeatedly asked a simple one would question "why" and it also came through with her lack of revoicing. Unlike Jill, Meredith did not revoice the majority of comments made in her classroom. The student voice is what is heard. These examples support Meredith's efforts to have more of a student-led classroom.

Meredith's vision of a student-led classroom became stronger as the year progressed and she was well aware when she did not meet her own expectations. Meredith recognized that her classroom discourse fluctuated between student-led

discussions and teacher-directed lessons. After Meredith received positive feedback on

her December enactment, she sent the following email to the instructor:

> I feel like I have to admit that the lessons that I do in class are not all
>
> representative of the lesson that I videotaped. I was really happy that the lesson
>
> went so well, but not all of them turn out that way. (Personal Email
>
> communications, December 15th)

Recall that Meredith's Late June, September, and December data sources all showed

evidence of Meredith facilitating discourse to elicit student thinking, whereas the mid-

June, October, and February did not. Below I provide the reader with an example from

February to provide contrast to the discourse in Episode I.

Episode II: Teacher-directed Lesson

Episode II was chosen to be a representative sample of the type of discourse that

took place in Meredith's more teacher-directed lessons (i.e., Early June, October, and

February). As you will see, this conversation was very procedural in nature and

Meredith's questions guides the students step-by-step, while she wrote these steps on the

Smart Board. Meredith used several gathering information questions, but perhaps most

notable is what is missing from this clip. Meredith did not use many discourse moves to

elicit student thinking nor did she invite other students to contribute comments or

evaluate their peers work. In fact, Meredith evaluated the student work in this clip.

This episode was taken from video that Meredith submitted for her final

performance-based assessment. In this unit, students were studying systems of equations.

The previous day students graphed systems of equations to find the intersection point.

This brief clip comes from a day when they worked with the substitution method. The following two equations were projected via a power point on the smartboard:

$$x + y = 5$$

$$y = 3 + x$$

65	*Meredith:*	Okay so we don't have to- you don't have to write this down but we can just talk about how we would solve this. Which equation is the easier one to solve for, Student 13?
66	*S13:*	Well the bottom one is already solved.
67	*Meredith:*	Yeah! That one is already solved for y, okay so then what are we going to do, yes?
68	*S13:*	Then you, oh wait, are you talking to me still?
69	*Meredith:*	Uhuh.
70	*S13:*	Yeah then you plug it into the top equation when you put x plus parentheses 3 + x end parentheses equals 5.
71	*Meredith:*	Awesome and then what would we do? Yeah, Student 14?
72	*S14:*	Well um since there's no number outside the parentheses you could just take down the parentheses and then combine like terms.
73	*Meredith:*	Okay, so then how would we do that?
74	*S14:*	Um x+3 + x equals 5 and then 2x +3 equals 5 now subtract 3 on both sides and then you get 2x equals 2 and then divide by 2 on both sides and then x equals 1.

[Meredith is writing all of the steps as the student is talking]

$$x+3 + x = 5$$
$$2x+3 = 5$$
$$\underline{-3 \qquad -3}$$
$$\frac{2x}{2} = \frac{2}{2}$$
$$x = 1$$

75	*Meredith:*	Okay and then what, yeah Student 15?
76	*S15:*	Then you plug what x equals back into the final equation.
77	*Meredith:*	Awesome. So then what does y equal?
78	*S15:*	y = 4 [Meredith writes y = 4 on the board]
79	*Meredith:*	So what is our solution?
80	*Student:*	One
81	*Student:*	Four
82	*S?:*	We have to check them guys, come on.
83	*Meredith*	Yeah guys, come on [joking voice]. So you check it by plugging it into both equations. Plugging it into just one does not count if you're going to check it just go for it and do both.

(Episode taken from Video 3 Part II- 1:16-1:38)

Eliciting and Using Student Thinking

In Meredith's commentary she notes that this particular video segment depicts procedural fluency, and that she did not pose any questions that addressed student thinking or conceptual understanding. During the first interview Meredith mentioned that she experienced tension regarding pacing on this unit. There were many snow days and delayed starts in the previous weeks, yet the school district did not adjust the testing schedule. Meredith knew her mentor was going to be evaluated on how the students performed on the assessment and that systems of equations would be on it. Meredith noted that these particular lessons were "more structured" and that she used a PowerPoint and was "showing them notes and having them write stuff down" (Interview II, p. 3). Meredith expressed this tension during the first interview as well, in the following quote:

> We HAD to give the test by the end of February and with ALL the two-hour delays and snow days I just felt like towards the end the only way to get information in was to just tell them. And so that was, a lot harder to do. Because I didn't want to do that but I knew that was what needed to be done because the student discovery and questioning them just takes so much longer even if it does in the long run benefit them further. But they had to be introduced to it because [Mary] had to give that test. (Interview I, Lines 340-6)

While it is clear that Meredith was under pressure due to time constraints, this was not the first time her data sources revealed procedural lessons that did not draw on student thinking. In fact, Meredith imposed her method and way of thinking on students in the early-June and October audios. During the June peer-role playing, instead of letting the student explain their erroneous thinking, Meredith told him to switch from fractions

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to decimals to solve the problem. Meredith noted the following in her reflection: "I still had him follow some of my mindset of how the problem should go, and I should have put more emphasis on him explaining to me what he did" (Audio 1 Analysis, p. 2). She recognized that she could have strengthened the interaction by simply allowing the student to explain his thinking first.

A similar situation happened during the October audio. Students were asked to solve for F in the following equation: $30 = (5/9)(F-32)$. Meredith had a student start explaining his work and his first step was to distribute the 5/9ths. While algebraically this is correct, it is not the most efficient way to solve this problem. Meredith interrupted the student to see if anyone did it differently, only to find out that all of the students used this method. She attempted to prompt the students in a different direction by posing the following leading question: "Isn't there something simpler that I could multiply both sides by to get rid of the 5/9ths?" (Line 140). Meredith noted in her reflection

> I need to get out of the mindset of "my way" being the correct way. Yes, multiplying by reciprocals is an easy step to get rid of the fraction instead of distributing, but that does not mean it is the only way and I do not think I should be forcing processes on the students. (Audio 3 Reflection, p. 8)

These reflective analyses forced Meredith to think more about what the students were thinking and her role in eliciting their thinking. In this last example, with the algebraic manipulation, Meredith really started to wonder about her students understanding of algebraic processes. She commented, "I am now questioning if they [students] are really understanding what we are teaching or if they are just good at realizing when to use various procedures and steps to find the solution" (Audio 3

Reflection, p. 9). These analyses also helped Meredith recognize when she took over the thinking for the students.

Discourse Moves

Meredith only used one discourse move during this brief segment—revoicing. We see Meredith use it differently than in the first episode. Here Meredith, uses it more similarly to the way that Jack would often revoice. She first evaluated the students comment (i.e., "Yeah!") and then reiterated what he said to emphasize his reasoning to the rest of the class. Like Jack, she did not repeat verbatim and in fact, included "solve for y" to clarify the statement. This, however, is the only discourse move that Meredith used in this clip. Again, Meredith was aware of this and mentioned in her commentary that she was leading students through the notes and that she did not attempt to elicit student thinking.

Question Types

Meredith only used one question type during this brief segment—gathering information (i.e., Lines 65, 67, 71, 73, 75, 77, 70). Meredith noted in her commentary that she never asked any probing or "why" questions that would require students to explain their work in this segment of the video. Again, this was typical in the data sources that were more teacher-directed. For example, during the early-June audio, Meredith only posed gathering information questions. She led her peer through procedures and asked several of recall questions such as, "When you add fractions, what has to be the same" (Audio 1, Line 13). Again, Meredith recognized that she did not use any probing questions to get at her peer's thinking.

Another feature regarding Meredith's questioning pattern that was illuminated in this brief clip is the way she would call on students. Meredith did not use student names as frequently as Jill. For example, Meredith would often call on students with a simple "yeah" and point or nod in the direction of the student to let them know she was giving them the floor. This was noticeable especially during the transcription of the audio segments, because it was difficult to tell which student was speaking. We see it causes some confusion in Episode II between Lines 67 and 68, where the student is not clear whether he was supposed to be responding to her prompt.

Discourse Practices

In these more teacher-led procedural lessons, Meredith struggled with classroom management. She had an extremely talkative group of eighth-grade Algebra students, and they enjoyed contributing to discussions and interacting. When Meredith would take the lead in more procedural lessons, there seemed to be a struggle for power. During these lessons, Mary did not help Meredith manage the student chatter. During the October audio, Mary jumped in a few times (Lines 31, 99) and raised her voice with the students; however, the students did not respect Mary's request and after a few moments of silence the side chatter and volume of the whole class would increase. Meredith also attempted to reign in the side chatter; however, her pleading attempts to get the student to stop talking were not effective (Lines 43, 52, 73, 98, 150, 181, 295).

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Meredith's Ideal Classroom Discourse

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Meredith mentioned in several of her reflective comments that she had a vision for the type of classroom discourse she wanted. During the May interview, Meredith was asked to identify several aspects of classroom discourse and how she felt she was

currently doing. She then was asked to identify where she wanted her ideal classroom to be on a continuum.

As shown in Figure 10 there is a large gap between Meredith's current role and her ideal role. When asked about this gap, Meredith mentioned that she was struggling with her current eighth-grade Algebra students and that they were "far too social" to be any further to the right on the continuum (Interview II, Line 283, p. 7).
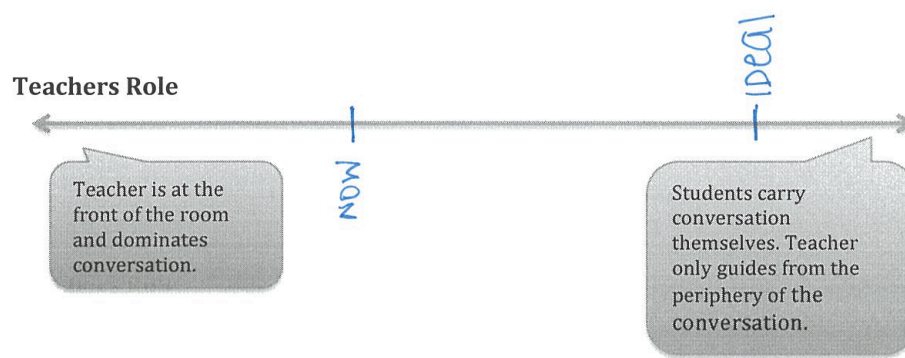
Figure 9. Meredith's Ideal and Current Role in Discourse

As shown by the placement of her ideal classroom, Meredith was very interested in student-led discourse; however she struggled to consistently implement this in her classroom. When asked what challenges she was facing, Meredith mentioned classroom norms. She noted that Mary had different norms, which is reflected in the following quote:

> …[Mary] is very traditional so they spent three months just taking notes and not really doing a lot of activities and so I think that starting something off that way would, make it a lot easier for them to actually do what I want them to do. (Interview II, Lines 351-4)

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Meredith implied that she was strongly impacted by several of the readings and videos from the two methods courses but she felt trapped under Mary's classroom structures. Meredith noted that she would have to "set some of it [ideas from the course] to the side for later because a norm had already been established in the classroom" and this norm did not align with Meredith's vision (Methods II Mid-course check-in, p. 1). Meredith indicated in her Methods II annotated bibliography as well as her final reflection that she was really inspired by one particular article entitled, "Enhancing the Learning Environment Through Student-led Mathematical Discussions" (Arbaugh & Avery, 2009). This article depicted a high school classroom where the teacher created an environment where the students led the discussion. This meant the students posed questions, with the teacher facilitating from the back of the classroom. Meredith noted that this "type of teaching allowed many different student thoughts and solutions to be shared and discussed" without the "teacher leading in the route that he or she wants the class to go in" (Methods II, Annotated Bibliography, p. 4). Meredith noted, "I would love to implement this into my classroom, whether it is this year or next year" (Methods II Course Reflection, p. 3).

This notion of a student-led classroom also appeared when Meredith reflected on a brief exposure to videos from international mathematics classrooms. The teacher candidates were asked to read sections of *The Teaching Gap* and to watch corresponding TIMSS clips from the United States and Japanese classrooms. Meredith noted, the following:

Watching the Japanese classroom, I felt a strong desire for my classroom to be similar to that…it truly did seem like a classroom created by all the research we

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have read about. The teacher was not the main voice of the class, but he also had

not disappeared into the darkness and ignored the students. He was still teaching

them, but the students were the ones who were making the class "go around".

(Methods II, Course Reflection, p. 2)

This quote shows Meredith had a strong sense of what her ideal classroom would

look and sound like. However, she acknowledged that creating classroom norms for a

group of student who are used to a mathematics class operating a certain way was

challenging. Meredith recognized that Mary did not have the classroom norms in place to

facilitate the type of student-led discourse she wanted; however, she was optimistic that

her future classroom could be student-led given the representations of practice she saw in

the methods course.

Conclusion

As the transcripts in this chapter showed, Meredith was able to bounce between

various discourse practices. In the recordings from mid-June, October, and February

Meredith did not achieve the type of classroom focused on student thinking that she

idealized. However, Meredith's late June, September, and December recordings all

showed evidence that Meredith was able to employ the discourse moves and questions

practices that could elicit student thinking and generate productive discussion. While, it is

clear that Meredith had the skills to enact these discourse practices, her context prohibited

her from enacting these practices on a more frequent basis. The classroom norms

established by Mary greatly impacted Meredith's opportunity to practice facilitating

productive discourse. Meredith was aware of her constraints but was critical of her

teaching practice, especially when it was more teacher-directed. Meredith's coursework

showed that she was able to critically examine her teaching practice. This makes the reader wonder what type of growth Meredith may have experienced had she been placed in context similar to Jack and Jill or with a mentor whose norms aligned with hers.

While Meredith did not achieve the student-led classroom that she had imagined, she still was quite successful in both methods courses as well as the MA program. Although the MA program certification would only allow her to teach middle school mathematics, Meredith took the secondary mathematics PRAXIS exam and passed on her initial attempt without any issues, thus she was certified to teach 6-12. Meredith accepted a job offer in a neighboring large suburban district teaching sixth-grade math. This district was the same district she attended as a student.

Chapter 8: Cross-case Analysis

This cross-case chapter is divided into three sections, which correspond to the research questions. The first section looks across the cases to explore question types and discourse moves that were infrequently used by the TCs. The second part of this chapter offers the reader more insight into the teacher candidates' perceptions of the methods courses, specifically the impact of various activities on the TCs' learning and enactment of discourse practices (i.e., the second research question). The third section explores common tensions—such as lack of time and resources—experienced across the teacher candidates as they learned about and enacted discourse related teaching practices (i.e., the third research question).

Infrequently Used Discourse Practices

Chapters 5, 6, and 7 focused primarily on identifying the shifts in each of the teacher candidates' discourse practices over the course of their preparation program using evidence from their audio/video recordings and written reflections (i.e., the first research question). These chapters discussed the question types and discourse moves that were used by the teacher candidates; however, they did not address what was absent. Looking across the cases it was clear that there were two questions types that were infrequently used by the teacher candidates—making the mathematics visible and encouraging reflection and justification. Similarly, I identify one discourse move—restating—and discuss its limited usage. Due to the limited use of these question types and discourse moves it was difficult to find patterns or identify any shifts that may have occurred.

Question Types Infrequently Used

Research suggests that a variety of question types can influence the "cognitive opportunities offered to students" (Boaler & Brodie, 2004, p. 781). The teacher candidates in this study showed more variation in question types than the in-service teachers in Boaler and Brodie's (2004) study. However, the data revealed that the teacher candidates infrequently used two questions types—making the mathematics visible and encouraging reflection and justification. While the candidates showed variety, these two question types that were infrequently used were higher-level questions.

The most infrequently used question type was encouraging reflection and justification. Since this is a higher-level question it is reasonable for it to occur less frequently than questions that gather information; however, the fact that it occurred less than 10 times in all of the data sources is surprising. These questions are the type that asks students to extend their thinking, generalize an idea, or prove a statement. These rich questions are what allow students to advance their thinking and to see larger themes; therefore it is crucial that students are experiencing questions at this level.

Another question type that was infrequently used was making the mathematics visible. These questions help students explore mathematical meaning and relationships as well as make connections between mathematical topics. Jack was the most prominent user of this question type. He used it to help explore mathematical meaning in his classroom. All of the TCs, however, used this question infrequently to make connections between mathematical concepts. In other words, they did not often pose questions that would allow students to link to previous mathematics they had studied. Making these connections are crucial for helping students develop understanding (NCTM, 2000).

Discourse Moves Infrequently Used

There was one particular discourse move—repeating—that was only used four times total in all of the data sources. In this move the teacher typically asks another student to restate a peer's comment. Chapin, O'Connor and Anderson (2009) identify several benefits of this move: more time for the class to process, a slightly altered re-explanation, proof that other students heard the comment, and shows the student their thinking is valued. It should be noted that this is not asking the student to agree/disagree or interpret the other students thinking. Jill and Meredith both used this move twice, while Jack never used it.

The two times Meredith used this discourse move was during her peer-teaching lesson. Meredith had simply asked, "Can you also explain what she just said?" to another student working in a group of four students (Video 1, Line 112). Using this discourse move allowed Meredith to see that her peer was, in fact, confused and did not follow the explanation. Meredith noted in her reflection that she was "really glad" she used the move because another group member jumped in and provided a "slightly altered explanation that was easier" for all of the group members to follow (Video 1 Reflection, p. 2). Despite her success with using this move, Meredith never used it in her field placement.

Jill also used the move twice, however, one time, which was highlighted in the episode in Chapter 6, was strictly for classroom management purposes. Below is an excerpt that depicts the second time Jill used this move in her field placement. Here Jill used the restating move to try to add some clarity to a student comment. It is interesting

to note that Jill comes back to Student 4 to provide ownership to the idea that is going to be put on the board.

115	*Jill:*	Okay, what about the relationship between circumference and area. What do you think Student 4?
116	*S4:*	[Had hand raised] They're both wholes, like area is--I mean circumference is the whole circle and area is the whole the inside.
117	*Jill:*	Okay I like where you are going with that. Can somebody put in their own words what they think Student 4 just said, cause I think it might have been a little confusing to some of your classmates. So Student 7 do you want to rephrase what Student 4 had said?
118	*S7:*	Yeah, circumference is the measurement around a circle and then area is the measurement inside the circle.
119	*Jill:*	So, Student 4 do you want to put what you said up on the board or Student 7's paraphrasing of your idea up on the board please…

(Episode taken from Video 3, 2:48-3:32)

While Jill makes clear why she is asking another student to restate (i.e., "it might have been a little confusing"), this discourse move is not natural in our everyday conversation.

As Ball and Forzani (2009) acknowledge, much of the work that teachers do is "unnatural" (p. 499). Asking someone to restate something someone else said is not a common conversation tool. It might be a confusing prompt if the audience does not understand the purpose. I hypothesize that this is one reason a repeating move like this might be infrequently used. If we want teacher candidates to use this move more often, it will probably require rehearsal so that it becomes more natural.

Perceptions of Methods Course Activities

This research sought to identify the TCs' perceptions of various activities from the methods course. In this section I begin by identifying a representation of practice that all of the teacher candidates identified as being the most influential experience from Methods I. Then, I discuss an activity that the teacher candidates did not perceive as

particularly helpful initially, however, the data suggest that it was useful in supporting

their initial reflections on their discourse practices.

Most Influential Experience of Methods I: Modeling

All three teacher candidates identified modeling by the instructor as the most

impactful experience in their learning about discourse-focused teaching practices.

Modeling discourse practices—via mathematical tasks—provided the teacher candidates

an opportunity to experience mathematical discourse as students, which allowed the

candidates to "figure out what discourse actually was" (Jill, Interview I, Line 46). As we

will see in the paragraphs below, the instructor's modeling provided a representation of

practice that showed the teacher candidates what was possible in terms of mathematics

classroom discourse.

In the first interview, each candidate was asked an open-ended prompt regarding

the most influential aspects of Methods I on their discourse practices. Meredith bluntly

referenced modeling, stating: "I saw how [the instructor] did it" in relation to posing

questions (Interview I, Line 21). Meredith recalled a specific experience from the first

day of Methods I when the instructor identified Meredith's questioning as exemplary.

The instructor was facilitating a whole-class discussion during which Meredith

questioned one of her peers. The instructor applauded Meredith's questioning during the

discussion and again mentioned it at the conclusion of the first class. Meredith found this

positive reinforcement instructive, stating it "triggered in my head that that was what I

was supposed to be doing" (Interview I, Lines 58-9). Meredith noted that this early

instruction on how to participate in a whole class discussion allowed her to continue to

practice this type of interaction with her peers as a student of mathematics.

Jack and Jill also both referenced modeling, but more indirectly than Meredith. Jill noted the most influential aspect of Methods I was "working through the task" (Interview I, Line 48) and Jack responded similarly. Jack specifically noted that the in-class discussions allowed him to see "that no two students really understand mathematics in the same way" (Methods I Reflection, p. 3). Jill also mentioned that it was the discussions with her classmates about the various solution methods that made for an impactful experience. Although Jack and Jill both specifically noted the mathematical task as the influential component, their elaborations showed that it was the ways in which they experienced the mathematical task that was more impactful. As mentioned in Chapter 4, this experience included TCs completing tasks individually and then sharing their work in small groups, as well as participating in a whole-class discussion around the task. In other words, the teacher candidates experienced aspects of the five practices as modeled by the instructor (i.e., *monitoring*, *selecting*, *sequencing* and *connecting*).

Jack and Jill both indirectly mentioned aspects of the five practices modeled by the instructor. For example, Jack stated: "In [Methods I] I really found that I was making connections that I wouldn't have made unless I talked with others" (Methods I Reflection, p. 3). While Jack did not specifically note the *sequencing* of solutions as impactful, it is likely that this is what allowed him to make connections. During Methods I, multiple representations were encouraged and non-algebraic solutions such as pictorial representations were privileged. Jack's initial approach to many of the mathematical tasks was algebraic, thus the sequencing of various non-algebraic solutions provided Jack an opportunity to make connections to his more standard algebraic solutions.

Jill, on the other hand, noted the instructor's use of monitoring during the mathematical task. However, this appeared as a tension for Jill because she felt she could not do the same type of monitoring in her seventh-grade classroom. Jill noted,

> I think back to our [methods] classes and when you would monitor us and like we would actually be talking about the material and you would walk and monitor whereas with my students I'm walking around monitoring I'm getting students back on task. (Interview I, Lines 784-7)

Jill recognized that her lack of monitoring directly impacted her whole class discussions because she ended up calling on volunteers to show their work instead of more strategically selecting solution methods.

The fact that all three candidates acknowledged modeling as the most influential experience on their learning about discourse related practice from the methods courses should not be surprising. All of the TCs' previous mathematical experiences had been more traditional lectures, so learning via mathematical discussions was a new experience. Moreover, the teacher candidates found most of these mathematical tasks engaging and, according to Jack, even "fun" (Interview I, Line 321). Also, the TCs completed a mathematical task almost every day during Methods I, with the five practices constantly being modeled (see Appendix L), whereas some of the other pedagogies (e.g., peer-role playing, peer teaching) occurred only once or twice during the course. Whether it was the quantity of mathematical tasks or specific occurrences such as the experience Meredith mentioned, it is clear that the modeling of classroom discourse practices by the instructor via mathematical tasks was impactful for the teacher candidates in learning about discourse-focused teaching practices.

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Undervalued Experience: An Approximation of Practice

At the end of the second week of Methods I (i.e., Session 8), the teacher candidates were challenged to practice making sense of student work in-the-moment by applying productive questioning practices. In this activity, their peers acted as students (see Audio 1 in Chapter 3). When asked during an interview specifically about the peer-role playing activity, it was clear that this experience was not well received by the teacher candidates.

All three teacher candidates expressed frustration with the interactional component of the activity. Although the TCs experienced discomfort with this activity it is clear from their written reflections that their investigations of practice allowed them to focus on their interactions with the student. More specifically, after listening to their audios each of the TCs realized that they imposed their own thinking on the student during the conversation instead of eliciting the student's thinking. Recognizing they had not elicited student thinking was an important first step for each of the candidates as they began to explore their own discourse practices.

Role-playing component. It appears that the teacher candidates were most uncomfortable with the role-playing component of the activity. Jill noted, "it was a little awkward at first cause you know we had just all met each other and now we're pretending to be students" (Interview I, Lines 75-6). Meredith similarly stated it was "weird because I knew that [he] knew how to do" the mathematical task (Interview I, Line 89). Meredith also commented that during the role-playing aspect of the assignment she felt that she "was asking questions almost for the ASSIGNMENT and not to help the student"

(Interview I, Lines 91-2). Thus, the inauthenticity of the peer playing the role of a student seemed problematic for the TCs.

In addition to the awkwardness of the role-playing interaction with their peers, the teacher candidates also expressed frustration with the in-the-moment nature of the activity. Jack noted that he "became a little frustrated" and "ran out of questions to ask the student in order to come up with the correct conversion" (Audio 1 Reflection, p. 2). Jill also recalled "getting mildly frustrated" (Audio 1 Reflection, p. 3) toward the end of the interaction. Jill identified a specific moment of the activity when she struggled to respond:

> One of the things that really stands out to me from that audio when [peer] said to me, "I don't know Ms. Jill I have a quarter in my pocket and that's 25 cents" and the fact that I had no way to respond to that. And then afterwards reflecting, I was like oh you know then I could have talked about if the dollar was the whole versus what's our whole for the minutes. So [the role playing activity] really forced me to kind of think about my way of approaching students and um kind of set me up, prepared to not be comfortable at all which is a regular thing in teaching is to be uncomfortable and to be okay being uncomfortable. (Interview I, Lines 79-87)

In retrospect, it is clear that Jill found the struggle during the interaction component of the assignment productive. Jack also found the activity more helpful after the fact stating:

> [the peer role-playing activity] was good because I remember thinking during the assignment that like no student would ever be that persistent and like that because she was honestly acting, but then when you actually see it in the classroom, that kind of stuff does happen. (Interview I, Lines 117-120)

While it is clear that Jack and Jill were frustrated initially with the activity, in looking back on the experience they found it more helpful than they originally realized. Meredith, however, still found the inauthenticity of the role-playing component problematic.

Analysis and written reflection component. The analysis and written reflection component of the assignment was fruitful for Jill and Meredith. All three candidates at some point asked questions that funneled the student thinking. For example, while Jack was able to identify the student error (i.e., misunderstanding the whole), he never unpacked the student thinking, which we see in the following excerpt:

> Yeah, exactly so now the one mistake I think that you made is this top one up here and I want you just to really think about, what exactly is one quarter of an hour? And then try the problem again and then come back to me and see where you go from there, okay? (Audio 1, Line 20)

Meredith similarly assessed the student thinking without actually letting the student share their thinking. She began the interview by asking recall questions, such as: "when you add fractions, what has to be the same" (Audio 1, Line 13). Partway through the interaction Meredith asked her peer to switch from fraction to decimal form, even though this was not the approach he showed in his work. Unlike Jack, the analysis and reflection component of the assignment allowed Meredith to recognize that she imposed her thinking. Jack recognized that he could have posed alternative questions, however, he offers alternate questions as a way to lead the student to see their error, not for them to share their thinking. Meredith, on the other hand, noted, "I still had him follow some of my mindset of how the problem should go, and I should have put more emphasis on him explaining to me what he did" (Audio1 Reflection, p. 2).

In terms of eliciting student thinking, Jill had the strongest start to the role-playing interaction. She simply began by asking the student to explain their thinking. However, Jill ended the conversation with several close-ended funneling type questions, such as: "Do you think we should fix our math up here?" "Do you see what happened?" and "Make sense?" Like Meredith, however, Jill also noted in her reflection that she took over the thinking, stating she "did too much leading" (Audio 1 Reflection, p. 3). Jill and Meredith clearly used the analysis portion of the assignment to examine their discourse, which was evidenced in their reflection. Their self-realization of the lack of attention to student thinking was a powerful experience. It was not clear whether this assignment pushed Jack to critique his practice in the same way.

The nature of the role-playing activity—as an approximation of practice—seemed to cause the negative reactions from the teacher candidates. Interestingly, Meredith felt that the peer-teaching lesson that took place at the end of Methods I was a more authentic approximation of practice, noting she "was ACTUALLY asking the questions of what they were doing in order to divide the fractions" (Interview I, Lines 123-4). Perhaps the level of difficulty of the mathematical task, fraction addition, impacted the perceived authenticity of the experience. The mathematics in the peer-teaching lesson was more advanced and the TCs encountered peers who were confused with the content during their lessons (see Appendix N for articles used during peer teaching). Although all of the teacher candidates desired a more authentic experience, the data show that these initial approximations of practice encouraged the TCs to reflect on their question types as well as the way they elicited student thinking.

Tensions Encountered

The teacher candidates encountered a number of tensions and constraints as they tried to implement discourse-related teaching practices. Many of the tensions boiled down to one issue—time—or more specifically, the lack thereof. The candidates expressed frustration with the lack of time for purposeful lesson planning. Additionally, the candidates expressed frustration regarding the availability of curriculum materials. These tensions directly impacted the teacher candidates' ability to implement discourse-focused teaching practices. However, the teacher candidates experienced these tensions differently depending on their context. Recall that Jack and Jill were enrolled in the ALT program, which meant they were the teacher-of-record for half of the school day and they did not have a mentor teacher. Meredith, on the other hand, was enrolled in the MA program and was placed with an experienced mentor. These different contexts impacted the way the lack of time and lack of resources were experienced by the teacher candidates. The primary sources of data for this section are the one-on-one interviews, which took place in February and May.

Lack of Time

All three teacher candidates experienced the issue of lack of time. Jack and Jill both felt overwhelmed by the coursework and field component of their preparation program. Jill made the following statement, which was followed by an audible sigh, "With first year teaching, full time grad student, there are days where I don't even know which way is up" (Interview II, Lines 25-6). This sense of being overwhelmed impacted their lesson planning, which in turn impacted their classroom discourse. When Jack was

asked what was preventing him from achieving his ideal classroom discourse he summarized these tensions nicely:

> The biggest thing it's my planning and time to actually think of things to do it. Cause when I'm crunched for time and I--you know went to grad school [classes] and stuff like that and I don't HAVE the questions ready and I don't feel comfortable to lead a discussion because I know the kids, if they're not engaged and stuff like that it will not go so well. So sometimes I, I make the CHOICE to do more leading of discussion with them you know chiming in cause, I'm never like up there just speaking to them. There's a lot of them giving me comments and stuff like that but getting to the point where THEY'RE really doing all the talking and asking all the questions and like FULL discourse with them. That's where I want to get but in order to do that you can't just come into a lesson and expect that to happen you have to have it prepared. (Interview II, Lines 859-69, emphasis in the original)

This quote provides evidence that as a novice teacher Jack has a sense of his role in facilitating productive discourse, however, due to his lack of preparation time he chose to teach in a way that did not align with his ideal practice. This notion of choice and teacher decisions aligns with one of Jack's takeaways from the "Orchestrating Discussions" article (Smith et al., 2009) where Jack noted, "every choice that the teacher makes has a purpose and it will help the lesson flow and help the students have a better understanding" (Annotated Bibliography, p. 15). Thus, Jack's quote shows that he actively chose to play a more dominant role in the discourse when he did not have time to prepare purposeful questions.

Jill echoed Jack's frustration with the lack of time for planning and how it impacted her decisions around discourse stating, "frankly sometimes it's just easier, like if you don't have a lot of time to really put in like really in-depth planning, being at the front delivering information is easier" (Interview II, Lines 275-7). Jill specifically noted that extra planning time would allow her to "think the questioning through" (Jill, Interview II, Lines 227-8). While Jill identified direct instruction as an easier route, she attempted whole class discussions in each of the data sources. Jill reiterated her struggle with lack of time for implementing the five practices for facilitating discourse stating, "Currently, I'm having trouble with all five stages, there just is not enough time in the day right now to thoroughly think through every single day's lesson" (Methods II Reflection, p. 2). Having the time to think through a lesson was one of the aspects of the June peer-teaching experience that Jill appreciated. Looking back on the experience Jill stated, "I wish in my everyday teaching I was able to put that much time into a lesson plan" (Interview I, Lines 112-3). Jill made a similar comment during the second interview about her planning for her program-level performance-based assessment. She claimed the process was "therapeutic", saying it felt good to invest such a significant amount of time planning and reflecting on her teaching (Interview II, Line 23). Both Jack and Jill mentioned their excitement for the following school year, when they would no longer be graduate students and would have time to more thoroughly lesson plan.

All three candidates expressed tensions regarding time in conjunction with their final program-level performance-based assessment. The reader has already been introduced to Meredith's struggle with time constraints (i.e., Episode II in Chapter 7). Recall that Meredith's frustrations were due to lack of instructional time, not planning

time. Meredith had contacted the instructor to gain access to some additional curriculum materials at the university (i.e., the Connected Mathematics Project curriculum). However, that winter was particularly difficult in terms of school closings. Meredith recalled the following:

> I unfortunately was doing a lot of my videoing when there was so much snow so a lot of them were during two hour delays so the classes were a lot shorter, but I had to keep going because [Mary] had her [district assessment] coming up. (Interview II, Lines 83-5)

Meredith continued, "I just felt like I was trying to get through the lesson instead of really trying to help them understand it" (Interview II, Lines 104-5). In general, Meredith was frustrated with the way she felt she had to adjust her lesson plans toward more procedural fluency due to the lack of instructional time.

Passing the performance-based assessment was a program requirement for graduation, thus making it high stakes. All three candidates felt pressed for time--either for the planning, instruction, or reflection—yet they invested significantly more time than they did for a typical daily lesson. This clearly shows that the candidates do not have enough time for daily planning. Even more interesting to note is that the teacher candidates all turned to resources outside the district curriculum for these lessons, which takes us to another tension experienced by the candidates.

Lack of Resources

All three teacher candidates taught in the same large suburban school district and presumably had access to the same district curriculum materials. Jack and Meredith both used the eighth-grade materials and Jill used the seventh-grade materials. Jack expressed

his frustration in our second interview when he noted that the textbook he was provided was more like "assignments" or practice problems and he occasionally provided it to students for extra practice, but he noted, as "a resource to teach with, we don't really use it" (Interview II, Lines 338-9).

All of the candidates mentioned some frustrations with the district curriculum guide. Meredith mentioned that she had a difficult time utilizing the guide. She stated,

I don't like the way that the [district] curriculum sets up in the those boxes and tables I just can't follow that…and so I try to look at that and I'm not really sure what I'm supposed to be teaching. (Interview II, Lines 512-19)

Jack and Jill both noted that there was a learning curve to using the district materials. Jack stated the following: "at the beginning it was like, where did this come from. And we weren't really sure about the curriculum document and how that worked and that's all stuff that we just kind of learned as we went along" (Interview I, Lines 195-8). Jill noted that it was a challenge "becoming familiar with what's available" (Interview II, Lines 62-3) due to the size (300 pages per unit) of the documents. Jill mentioned that she was teaching the third unit (of five) before she noticed the section on additional materials that she was supposed to be covering in her honors sections. In short, the curriculum materials overwhelmed the teacher candidates.

Unlike Meredith, Jill viewed the curriculum guide as "a wealth of information" (Interview II, Line 562). In fact, Jill noted the following regarding the scope and sequence: the "curriculum guide does do a really good job of telling us where the students are coming from in the 6th grade and where they are going in the 8th grade" (Interview II, Lines, 533-5). While the guides may have provided the scope and

sequence, it appeared that Jack was unable to locate it. During our final interview Jack commented that he "should go back and look at the 6th and 7th grade curriculum before next year" (Jack Interview II, Lines 1135-6) so that he had a better sense of what content was covered. It is evident that all three candidates could have benefited from more specific guidance on what the district curriculum guides contained, and how to utilize them.

Additional resources. Aside from the district curriculum, all three candidates mentioned accessing materials from other sources. When Jack talked about his collaborative planning he stated the following: "we kind of create our own stuff or get stuff from Pinterest or something else like that" (Interview II, 339-340). Jill also said she occasionally used Pinterest in addition to MARS tasks, Share My Lesson, Teachers Pay Teachers, NCTM-illuminations, and the Teaching Channel. Jill made the following comment regarding outside resources: "I've taken a few of the MARS activities and modified them for my class and that's helpful because they have really good questions" (Interview II, Lines 228-30). During the interviews Jill noted that the two lessons represented in her field placement videos were pulled from other sources.

All three teacher candidates expressed interest in the Connected Mathematics Project (CMP) materials. Jill and Meredith made specific trips to the university to review units from this curriculum. While Jack did not access the CMP materials during the fall semester, he commented during the last interview that he was really impressed with the CMP unit he was exploring for his spring methods course and that he planned to use the materials next year.

Resources from Methods I and II. Additionally, all three candidates mentioned using resources from the methods courses. Each of the teacher candidates in Methods I was asked to upload their lesson plan and resources from their peer-taught lesson to a shared Google drive folder. The topics were distributed so that there were three to four lessons each for sixth grade, seventh grade, eighth grade, and Algebra I (see Appendix N for list). The candidates did not know their placements at that time in the program, so this shared folder was created with the intention that each TC would start the school year with a handful of lessons for whatever grade level they were assigned. During an interview Meredith said she returned to this shared folder to find materials to show her mentor; however, she did not use any of these materials in her field placement for the lessons that were recorded for this research. Jack used materials from this shared folder for his performance-based lesson (i.e., modeling to predict Robert Wadlow's height). While Jill did not use any of the shared items during the lessons she recorded, she used other resources from the methods courses. As previously mentioned in Jill's chapter, her first audio recording from her field placement was a warm-up where she experimented with a problem from one of the readings in Methods II--"Moving Beyond Teachers' Intuitive Beliefs About Algebra Learning" (Nathan & Koedinger, 2000). Jill's second audio recording in her field placement also used materials from Methods II. Jill decided to use her group's lesson study materials on calculating tax and tip. While the candidates seemed pleased with the resources that were shared during the methods courses, Jack expressed frustration noting that he struggled to access these materials by himself after the course.

Conclusion

This chapter reached across the cases to pull out themes regarding infrequently used discourse practices, influential activities from the methods courses, and the tensions encountered by the TCs. The finding that TCs infrequently used higher-level question types seems related to the tensions regarding time. Low-level questions tend to "emerge naturally," while higher-level questions require advance planning (Chapin, O'Connor & Anderson, 2009, p. 181). The teacher candidates in this study acknowledged that they did not have adequate time to plan questions for their daily lessons. Moreover, they struggled to use the district curriculum guide, which likely impacted their ability to see the larger mathematical landscape. Posing questions that make connections between mathematical topics would be extremely challenging without a vision for the scope and sequence of each grade level.

As discussed in the second half of this chapter, there were several components to the methods courses that exposed the teacher candidates to discourse-focused teaching practices. These experiences allowed the teacher candidates to observe and practice some of the "unnatural" aspects of teaching, such as posing questions to which one already knows the answer (Ball & Forzani, 2009, p. 499). The teacher candidates shared similar previous mathematical experiences, which did not incorporate classroom discourse and value student thinking. The teacher candidates overwhelmingly found experiencing mathematical discourse as modeled by the instructor to be influential in their own enactment of discourse practices. Jack, Jill, and Meredith saw the instructor monitor, select, sequence, and connect multiple student solutions. Moreover, the TCs observed discourse moves such as adding on to peers' comments and wait time. Thus, modeling

via mathematical tasks provided the teacher candidates with a representation of what was possible in terms of discourse in the mathematics classroom. While modeling allowed the teacher candidates to experience discourse-focused teaching practices, the methods course assignments allowed the TCs to enact and reflect on their discourse practices. The peer-role playing activity provided the teacher candidates with the opportunity to feel some of the discomfort when responding to student thinking in the moment. Moreover, the TCs found their natural instinct was to pose leading questions, which proved to be unproductive in terms of eliciting student thinking. Thus, the methods class provided several instances for the teacher candidates to experience some of the "unnatural" aspects of teaching in hopes of making them feel more natural.

Similar to Kennedy's findings, there were many "circumstances of teaching" that constrained the TCs (2005, p. 232). The teacher candidates all had a vision of their ideal classroom and what was possible; however, there were school level factors that prevented them from achieving their ideal classroom discourse. As the teacher candidates stated, the lack of time to plan and prepare impacted their instructional decisions around discussions. This should not be surprising, and has been noted in research. It is nicely summarized by Smith and Stein (2011) in the following statement: "to have a productive mathematical discussion, teachers must first establish a clear and specific goal with respect to the mathematics to be learned and then select a high-level mathematical task" (p. 19). Setting specific goals and accessing rich-task—often referred to as practice 0— can be time consuming if these materials are not readily accessible. The frequency with which the teacher candidates turned to outside resources shows that they perceived their current materials to be lacking.

A rich task is necessary but not sufficient. As Boaler and Humphries (2005) acknowledge, "The initial tasks that teachers use are critical in setting up particular terrain that students will explore, but the questions that teachers use to guide students become the pathways that students walk along and that shape their experience of the terrain" (p. 36). These questions that teachers pose do not magically appear, even experienced teachers must strategically plan ahead. It was clear that Jill recognized the importance of the additional amount of planning that went with rich mathematical tasks as she sought material that included probing questions. While Jill found purposeful questions within the MARS materials, this type of detail is not always present. It was clear that all of the candidates realized that thinking through a lesson in this amount of detail required significant time investment.

Recognizing the time commitment required for one lesson, one must wonder how we expect novice teachers to weave these lessons together to create a coherent curriculum. As Cohen (2011) acknowledges:

> Teachers who work with well-developed curricula, the means to collect timely evidence on students' work, and a repertoire of academic tasks that is referenced to curricula and assessments have less difficulty teaching ambitiously than teachers who must invent these resources. Those who aspire to high-quality work must, to an extent that would be remarkable in other skilled occupations, devise it themselves. (p. 63)

The question one wonders is how teacher preparation programs can help teacher candidates manage the time commitment required for locating, creating, enacting and reflecting on thoughtful lessons that enable productive mathematical discourse. The next

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chapter proposes suggestions as well as other implications this study revealed related to

teacher preparation.

Chapter 9: Discussion and Implications

This final chapter begins with a summary of this dissertation study. I then discuss some of the difficulties I encountered when trying to work with a common language and framework. I specifically reference two of the issues that occurred as I tried to use the learning cycle as a framework. Then, I explore implications of the findings of this study for teacher education. I propose course-level and program-level improvements as well as raise issues related to larger challenges in the field of education. Lastly, I identify research needed in light of the findings of this study.

Summary of the Study

This study explored three teacher candidates' learning and enactment of discourse-focused mathematics teaching practices during a year-long post-baccalaureate teacher preparation program. The teacher candidates enrolled in two consecutive mathematics methods courses that were rooted in the belief that teacher candidates need opportunities to learn about, practice, and reflect on core practices of teaching. The following discourse-focused mathematics teaching practices (MTP) were the emphasis in course activities during this study: elicit and use evidence of student thinking, pose purposeful questions, and facilitate meaningful mathematical discourse. This case study research aimed to address the following research questions:

1. What are the shifts in teacher candidates' discourse practices when enacting mathematics instruction over the course of a 13-month post-baccalaureate program?

2. How do TCs perceive various activities in the methods course influencing their learning and enactment of discourse-focused mathematics teaching practices?

3. What tensions do TCs encounter as they learn and enact discourse-focused mathematics teaching practices?

Analysis of the audio and video recordings provided evidence that all three teacher candidates were able to incorporate discourse practices that allowed them to unpack student thinking. As was evidenced in the individual case study chapters, the shifts in discourse practices varied by candidate. Analysis of the data sources revealed Jack shifting toward a more facilitative role, which allowed for more student voice and thinking to be shared. Jill made minor refinements in her discourse practices such as eliminating her evaluative tone. Meredith demonstrated her ability to oscillate between student-focused conversations and teacher-directed procedures given the constraints from her placement. The teacher candidates identified modeling by the instructor as one of the most influential activities in the methods courses. Analysis of the data revealed that the role-playing activity, although inauthentic, assisted the teacher candidates in recognizing their initial discourse was not eliciting student thinking. Finally, the teacher candidates revealed tensions associated with lack of time and lack of resources.

Similar to Ghousseini's (2015) findings, this study demonstrated that these teacher candidates were capable of enacting discourse-focused mathematics teaching practices early in their teacher preparation programs. Moreover, this study provided evidence that teacher candidates can analyze and reflect on their own teaching in order to improve their discourse practices while concurrently enrolled in a preparation program.

Below I describe some of the issues that I encountered through the study as well as implications for the field of teacher preparation.

Working with a Common Language and Framework

The call for a common language and framework seems like an obvious first step for the field. The notion is to have a framework and a "common language for describing how teachers learn to practice and the pedagogies teacher educators enact to support teachers in learning to practice" (McDonald et al., 2013, p. 381). Throughout this study I attempted to use both the framework and common language established by McDonald and colleagues. Many of the tensions I experienced stemmed from trying to use the Cycle for Learning Core Practices (see Figure 11). Below I will highlight two of these issues.

Figure 10. Cycle for Learning Core Practices (McDonald et al., 2013, p. 382)

The Actors: Teacher Candidates and Teacher Educators

Recall that the goal of the Cycle for Learning Core Practices framework was twofold: to describe how teachers learn and to identify the pedagogies teacher educators' use. In retrospect, it seems obvious to me that this cycle should reflect two actors—the teacher candidate and the teacher educator. However, the graphic published in the 2013 article seems to conflate the two. For example, in the top right quadrant, two of the pedagogies identified to be representations of practice are modeling and examining video exemplars. I infer that the modeling is to be enacted by the teacher educator, whereas the examining of video exemplars is to be completed by the teacher candidate. Clearly, the teacher educator plays a role in preparing the materials for both of these pedagogies; however who is doing what actions is not clearly established by the framework. A similar issue arises in the top left quadrant. Here the teacher candidates are doing the reflecting on their practice, but the role of the teacher educator is not clear. I assume the teacher educator would be providing some type of feedback on these analyses, however, the current framework does not indicate this. Thus, the framework could be improved by identifying the role of the teacher educator and the teacher candidate in each quadrant.

As previously discussed in Chapter 2, this framework was built from prominent research and language that the field has been using (i.e., representations of practice, approximations of practice, and investigations of practice). However, there seems to be a missing component—the decomposition of practice (Grossman, Compton et al., 2009). The notion of decomposition is not represented in this framework nor is it mentioned in the publication. However, it is likely that the teacher educator has already decomposed a specific practice prior to identifying an appropriate representation of practice. In showing

a video exemplar the teacher educator has likely labeled and identified practices or moves for the teacher candidate to notice. For example, the video exemplar may be used to show a teacher facilitating a whole class discussion. The teacher educator may have previously labeled various discourse moves and the video could be used as a way for the teacher candidates to decompose the practice seen in the video by identifying these discourse moves. Here again, we see an example of how both the teacher educator and the teacher candidate are actors in this learning cycle. One potential solution would be to include an additional outer ring that would specifically note the role of the teacher educator and to leave the inner ring for the role of the teacher candidate.

Identifying the various roles of both the teacher candidate and the teacher educator may make the Cycle for Learning Core Practices more useful for teacher educators. For example, the framework was proposed for "orienting the pedagogy of teacher education" (McDonald et al., 2013, p. 382). What is not clear to me was whether it is supposed to be used as a planning tool for teacher educators or as a communication tool to map out a process for dissemination to other teacher educators. Initially, I saw this framework as a planning tool; however, in writing up Chapter 4 of this dissertation it became apparent that I used the framework more as a communication tool. It was a way to use common language to describe what I did, but it I did not use it as a way to develop course activities. Perhaps if the framework further articulated the role of the teacher educator it might be more useful as a dissemination tool between teacher educators.

The Core of the Learning Cycle: Instructional Activities or Core Practices

One of the reasons I was attracted to this framework was the centrality of core practices. In the original learning cycle, the core practices are at the heart of the learning

cycle. Thus, the various pedagogies are used to help the teacher candidates learn about, practice, and reflect on the actual core practices identified. McDonald and colleagues expected that the core practices would be woven into an "enact-able activity" or "instructional activities," where instructional activities were defined as "containers that offer novices an opportunity to try on core practices without having to create that opportunity themselves" (p. 382). Recall from Chapter 2 that instructional activities at the secondary mathematics level have not been articulated in the literature at this point. The generic definition of instructional activities, and the varying grain size of those currently being used seems that many activities currently used in teacher education could serve as "instructional activities."

McDonald, Kazemi, and Kavanagh, along with other colleagues at the University of Washington, have created the Teacher Education by Design website (tedd.org). This website identifies several updates to the Cycle for Learning Core Practices. First and foremost the title has changed and they now refer to it as the Learning Cycle. The revised cycle no longer appears to be something one can begin in any quadrant. The current quadrants are labeled one through four suggesting that there is a specific order to events. The most dramatic change for me is that the center is no longer identified as core practices. The four components—introduce, prepare, enact, analyze—are now centered on instructional activities. According to the website, each instructional activity would contain one or more core practices.

Figure 11. The Learning Cycle (University of Washington, 2014)

This change—to forefront the instructional activity—concerns me. The teacher candidates now are introduced to an activity, prepare to teach the activity, enact the activity, and then analyze the enactment of the activity. Here the emphasis is on the activity. Take for example, choral counting. According to the materials on the website, teacher candidates would work on the following core practices: elicit and respond to student's reasoning, teach toward an instructional goal, orient students to one another's ideas about the math content, and use mathematical representations. Practicing this instructional activity several times would allow the TCs to become very good—even perhaps routine experts—at leading choral counting, but it is not clear how each of these embedded core practices would then transfer to other situations. The issue of transfer is one of the critiques of the core practice movement (Hiebert, & Morris, 2012). Teacher education scholars recognize that there is much research to be done in terms of

understanding how best to decompose and sequence specific core practices so that teacher candidates develop adaptive expertise (Janssen, Grossman, & Westbroek, 2015).

As discussed in Chapter 4, I did not use this revised cycle in this research. It is important to have the core practices at the center of the learning cycle, if core practices are the focal idea. Teacher candidates should be introduced to a core practice, prepare to teach the core practice, enact the core practice, and then analyze the enactment of the core practice. This focus on a core practice allows for teacher candidates to work on the core practice in their field placement regardless of what content they might be covering. For example, all of the TCs in this study collected audio from their field placement where they could focus their attention on posing purposeful questions. If instead we had been preparing for a specific activity (e.g., number strings) it is unlikely that they all could have used their field placements as a place to study their own practice.

Core Practices and Practice-based Teacher Education

While core practices were used as the center of the learning cycle for this research, it should be noted that the practices were nested. Recall from Chapter 2 that the three discourse-related practices were viewed as subsets of each other for this research; eliciting and using evidence of student thinking was at the center. Each time the teacher candidates focused on posing questions, they were asked to do so with a goal of eliciting student thinking. For example, when the teacher candidates analyzed their question types, their analyses went beyond classifying questions. The teacher candidates were expected to explain what their questions allowed them to learn about student thinking.

Thinking of these practices as nested was perhaps most important because the central practice of eliciting student thinking became a common instructional goal. Having

an instructional goal meant that the core practices were not the focus for the sake of simply practicing the practice (e.g., to get better at posing questions). This type of emphasis could result in a checklist approach to teacher education, which is counter to the responsive teaching that underlies the current practice-based approach. Instead, the broader goal was always to use these three discourse-focused practices in order to put student thinking about mathematics in the foreground of the classroom discourse.

Additionally, the three discourse-focused practices identified in this study worked well to support preservice teachers in reflecting on and improving their practice. A discourse focus allowed each teacher candidate to easily capture audio and video data from their placements for analysis. Other mathematics teaching practices (e.g., use and connect representation or build procedural fluency from conceptual understanding), while important, may be harder to capture in small segments on any given day. Thus, the three nested practices seem promising for future use in teacher preparation.

Implications for Teacher Education

The TCs in this study encountered many constraints that impacted their learning and enactment of discourse-focused practices that could be informative for the field of teacher education. I begin by returning to the two constraints identified in Chapter 8 that were most salient for the teacher candidates: time and resources. These two tensions were closely related, in that the teacher candidates invested a great deal of time locating materials due to a lack of resources. I examine structures within and beyond teacher education to identify ways to eliminate or reduce these tensions. Below I explore four areas that have the potential to alleviate tensions related to time and resources: emphasize

K-12 curricular coherence, foster collaboration between candidates, align program-level

structures, and support induction.

Emphasize K-12 Curricular Coherence

The findings of this dissertation study suggest that novice teachers struggle to

pose questions that make mathematical connections. I hypothesize the lack of this

question type was due to the TCs' lack of vision for the larger K-12 mathematical

landscape. Questions that make connections between mathematical concepts are

particularly difficult if you are unfamiliar with the scope and sequence of specific

mathematical classes. Given that TCs are novices, they are likely unfamiliar with the

content their students studied in previous years. The TCs are not to blame for a lack of

curriculum coherence; this issue is due, in part, to the U.S. education system. In the

United States, education is controlled at the state level; however, curriculum is controlled

at the district level. Teacher preparation programs are preparing teachers to teach in

different districts and potentially different states. Novice teachers in Shanghai, for

example, have common curriculum materials with teacher guides that emphasize

"important", "difficult" and "hinge" points of specific mathematics topics (Paine, Fang,

& Wilson, 2003, p. 50). Since the United States will likely never have a national or state

level curriculum, we need to find ways to assist TC in developing curricular coherence.

Teacher educators may be able to foster connections for TCs by leveraging the

CCSSM. In attempting to be more focused, the authors of CCSSM have identified fewer

standards per grade level and these standards are intended to build on each other to create

a coherent set of K-12 standards. While this is not the same as national curriculum, I

hypothesize that teacher educators can use these standards to help TCs make connections within and between grade level domains.

As a teacher educator who recognizes the importance of questions that help students make connections between mathematical topics, I sought to find ways the methods courses might help TCs see the larger landscape. In teaching a subsequent section of Methods I, I created an overview that identified the clusters (i.e., groups of related standards) and domains (i.e., groups of clusters) for each grade level (see Appendix R for example). I used this as a reference point throughout the revised Methods I. For example, each mathematical task completed during the methods course was listed in an appropriate grade-level domain. The final peer-teaching lessons were also located within the appropriate grade level and domain, thus creating a shared resource for the TCs. At the completion of Methods I, each TC had a list of mathematical tasks that were appropriate for specific grade-level domains. The hypothesis was that the repeated location of standards within grade-level domains, as well as a shared artifact, might help the TCs become more familiar with the CCSSM and the content presented at each grade level so that they could more readily see connections. The use of this overview document is one simple way for teacher educators to support teacher candidates in seeing the larger mathematical landscape; however, this is not enough. Teacher educators need to explore more ways to help TCs develop a curricular vision and make connections earlier in their careers.

Foster Collaboration between Candidates

The findings of this study suggest that supporting more thoughtful and thorough lesson planning experiences impacts TCs' discourse practices and encourages sharing and

collaboration between TCs. While I was not aware of any direct collaboration for their performance-based assessments, I do know that resources were shared for these lessons. For example, Jack used a lesson idea that one of his peers presented in Methods I for his performance-based assessment. Both Jack and Meredith referenced their peers' materials from Methods I as resources for their field placements. Similarly, Jill used many of the resources from Methods II. The idea of sharing materials and collaborating with colleagues was encouraged throughout both courses (e.g., group lesson study), but it does not appear to have been taken up in the field placement to its full extent.

The candidates in this study were often planning by themselves (even Meredith) and were often searching the web for resources. Collaborating with a peer could help the TCs sort through the plethora of materials on the Internet and it might help ensure they are using quality materials. In general, more collaboration could help with both the tensions regarding lack of time and lack of resources.

Align Program-level Structures

While I was fortunate to have two consecutive methods courses for this study, it soon became apparent that this was not sufficient. Practice-based teacher preparation cannot exist solely at the course level. Practice-based teacher education must be a program-level endeavor. Programs could support the efforts of practice-based teacher education by having instructors model the practices throughout coursework and by providing opportunities for TCs to enact and reflect on discourse practices with the support of their field supervisors and mentors. Programs could also promote collaborative lesson planning by creating grade-level cohorts.

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The TCs positive reaction to the instructors modeling in this study suggests that the mathematical methods course should not be the only place that the TCs experience discourse-focused teaching practices. It would be beneficial if the mathematics content instructors were also modeling these practices for the TCs. Discourse-focused teaching practices also are not unique to secondary mathematics; they are also important at the elementary level as well as in other content areas (e.g., science, social studies). Therefore, general education instructors (e.g., diversity, reading) could also be modeling these practices. The TCs should experience discourse-focused practices as students via modeling by their instructors in classes throughout the program.

In addition to the instructors' modeling, TCs should be given opportunities to enact and reflect on these practices in field placements. Therefore, the university field supervisors and mentors should also be aware of the practices being emphasized in the program and support the TCs with their implementation. The program-level assessments could also provide a space for TCs to enact and reflect on their discourse practices. In this study, the final video recording was, in fact, a program-level requirement in which TCs had to address prompts related to their classroom discourse. Methods instructors, field supervisors and mentors should reinforce and support discourse practices.

One of the biggest tensions the teacher candidates faced in trying to learn and enact the three discourse-focused practices was lack of time. While there are many larger school structures that preparation programs do not control (e.g., length of planning period), changes at the program level have the potential to assist with some of the time constraints. Take for example lesson planning, which has long been an activity of teacher preparation programs. The TCs thought they needed to create lesson plans from scratch

instead of using or improving existing resources. Moreover, there was often a perceived sense of cheating when it came to sharing lesson plans. Instead of asking the TCs to individually create and submit several lesson plans as methods course assignments, preparation programs should focus on developing candidates who are critical consumers of existing materials.

Teacher preparation programs should be encouraging more collaboration during lesson planning, as this is ideally what is expected in the profession. Early knowledge of field placements is another area where a program-level change could impact teacher candidates' collaboration and curricular coherence. If the teacher candidates knew their grade level or course placements during the Methods I course, then they could focus their attention and assignments on specific mathematical topics. For example, a TC's final peer-teaching lesson could serve as a rehearsal for lesson that they would later teach in their field placement. Similarly, the teacher candidates could also focus assignments from their other coursework (e.g., reading and diversity courses) on things they could use in their field placements. As mentioned in the previous section, the TCs could be grouped with peers assigned to the same grade level to foster collaboration from the beginning of the program. While there will always be last-minute adjustments, the majority of the candidates would begin the school year with an overview of the big mathematical content for their assigned grade level as well as one planned and rehearsed lesson.

Support Induction

The suggestions above regarding better alignment to reduce tensions around the lack of time and lack of resources could be extended beyond the preparation program and into the induction phase. I identify three areas where preparation programs could work

with districts to support novice teachers in induction programs: record videos, align evaluations, and hire strategically.

Each TC completed a performance-based assessment that contains video recordings and analysis of their teaching. These artifacts should travel with candidates as they enter their first year of teaching so that districts can utilize the novice teacher's strengths and identify their weaknesses. This would allow the district to provide more strategic professional development for novices. The TCs should be encouraged to continue to video record and to critique their own practice. The teacher candidates in this study were extremely critical of their practice, and this allowed them to improve their practice. Realistically, novice teachers are unlikely to video record and reflect on their practice if not supported by the district.

Preparation programs and districts should work together to align evaluation tools. Ideally the evaluation tools used by university supervisors should mirror the tools used by administrators for novice teachers. However, this would require similar beliefs and shared understandings of different types of instruction (e.g., student-centered instruction). If the teacher candidates were being evaluated in their first year of teaching on the practices that were emphasized in the preparation program, then these ideas could be reinforced.

Preparation programs should encourage candidates to seek jobs that align with their expertise. Both Jack and Jill were hired by the district and asked to stay in the same building and teach the same grade level for the subsequent school year. The school-level and grade-level knowledge that Jack and Jill bring to their first full year of teaching will put them well ahead of a typical new hire. Meredith, however, was hired by a different

district and will be teaching a new grade level. While there is a lot of general knowledge that will transfer, Meredith will be using all new materials and navigating new district-level documents. As a novice teacher, Meredith will likely be investing a tremendous amount of time preparing for her new position and her grade-level expertise that she has developed from her internship will not be used to its full capacity. While I have no doubt that Meredith will be successful, I worry that her first year will be unnecessarily exhausting.

I should clarify that I am not advocating for teachers to solely focus on one grade level or course their entire career. In fact, I believe the opposite. I think it is important for teachers to experience a variety of courses and grade levels so that they will have a more complete picture of the larger curricular landscape; however, this should happen gradually as they become more comfortable and experienced. Novice teachers should not be expected to juggle multiple preps in their first year, if it can be avoided. In fact, novice teachers should be given reduced workloads during their induction years. This would perhaps give them more time to collaborate and more time to reflect on their practice.

Generalizability

While the goal of this study was not to make any generalizable claims about teacher candidates' discourse-focused teaching practices, I do intend for the study to demonstrate that novice teachers can enact and reflect on their discourse-focused teaching practices in contexts with diverse learners. Recall that the teacher candidates in this study had field placements in a large suburban district. Hillside Middle School was a majority Hispanic (67%) Title I school with 78% of the students eligible for free lunch and Meade Middle School was majority African American (61%) with 24% of the

students eligible for free lunch. The teacher candidates in this study were able to successfully navigate classroom discourse in these contexts.

However, it is important to note that not all teacher candidates in this cohort were as successful. As the instructor of record, I listened to the audio recordings, watched the video recordings, and read the analyses of all sixteen teacher candidates enrolled in Methods II. While most of the candidates experienced some type of improvement in their discourse practices, there were some who struggled with classroom discourse due to difficult settings. Recall that Teacher Candidate #8 was removed from the selection pool because he had been placed in an under-resourced classroom. He had 16 seventh-grade students (13 males) who were all labeled as ESOL and under-performing by the district. Additionally 9 students were also identified as struggling readers. He was in the ALT program so he was the teacher of record and there were no additional supports provided for his classroom. Teacher Candidate #9 also struggled with classroom discourse and was placed with a mentor who had poor classroom management. The program removed her from this placement prior to the end of the fall semester. These challenging contexts impacted these TCs' ability to enact and study productive classroom discourse. Therefore I want to recognize that the three teacher candidates focused on in this study were selected in part because they were able to navigate their placement contexts successfully. However, it should be noted that these contexts were not unusual in their support of teacher candidates or shifts in discourse patterns.

Lastly, I want to acknowledge that the selection of these particular cases resulted in particular findings related to shifts and patterns in discourse practices. A different set of three teacher candidates would likely provide different shifts and patterns, thus not all

results regarding TCs enactments and reflections are intended to be generalized. For example, Jill's frequent use of revoicing seems likely to be unique. As the university supervisor for several of the other candidates, I can speculate that other themes and patterns would have arisen if other cases had been selected. For example, I believe that had Teacher Candidate #10 been chosen her shift away from evaluative comments would have been a salient theme, and Teacher Candidate #6's shift in discourse would have likely been linked to her willingness to explore student thinking on the spot. As these examples, suggest, I believe the actual discourse patterns and areas of improvement would differ for each candidate, and I do not intend the three patterns of Jack, Jill, and Meredith to represent all possible trajectories or patterns of growth around novices' use of discourse practices.

Future Research

This dissertation study resulted from several years of conversations with fellow graduate students and faculty members. We have been reading and discussing core practices and more broadly rethinking teacher preparation. I relied heavily on the current scholarship around practice-based teacher education and this project represents my attempt to translate this research into teacher education practice. While this research process has been very informative, it raised many more questions than this dissertation was able to address. There are several theoretical questions as well as more practical questions that need to be explored in future research.

In terms of theory, there is much research to be done around specific core practices and The Learning Cycle. As addressed previously, scholars need to examine how the different foci of the learning cycle (i.e., core practice or instructional activities)

might impact teacher candidates' learning. Perhaps different foci will be beneficial in different contexts. For example, it seems likely that the grain size of the core practices that are being learned could impact the ways in which they are learned. Teacher educators also need to more closely examine how specific activities and experiences in the methods courses impact teacher candidate learning.

On a more practical note, this study revealed that time constraints were significantly felt by the teacher candidates. While suggestions regarding program-level changes and course-level changes were made, we should also consider the use of more technological tools. In this study the teacher candidates gathered and transcribed video and audio recordings from their classrooms. While this process helped them analyze and reflect on their own practice, we should also look for tools that might make this process more manageable. Are there tools or frameworks (e.g., four question types versus nine question types) that would make these analyses more meaningful? For example, is the new Analyzing Teacher Moves guide (Correnti, Stein, Smith, Scherrer, McKeown, Greeno, & Ashley, 2015) more useful in assisting teachers in identifying patterns in their discourse? Is it more beneficial for teachers to explore their talk turn patterns than their discourse moves as a way to encourage more student discourse?

On a personal note, I would like to reach out to Jack, Jill, and Meredith to discuss their first-year teaching experiences. As their instructor, I considered these three teacher candidates to be well launched beginners so I would like to know what tensions they encountered and what supports (e.g., induction programs) they received. I would also inquire about their discourse practices and, in particular, their use of questions that make connections. Jack and Jill were assigned to teach the same grade level as their internship

placements, so exploring how their curricular knowledge impacted their lesson planning and the questions they posed could be illuminating. Finally, I would be interested to learn how all three candidates managed their time as first-year teachers and to what extent they collaborated with their cohort and current colleagues.

Due to IRB constraints and an attempt to keep this study manageable, this research did not directly address K-12 student learning and engagement. The ideas for future research suggested above focus on teachers and their discourse practices; however, future research could and should explore how K-12 students experience these discourse-focused teaching practices. It is important for researchers to examine how specific discourse-focused teaching practices impact students in terms of developing their mathematical understanding as well as dispositions. Researchers may find that certain student populations (e.g., special education students, ESOL) may struggle with the verbal aspects of classroom discourse and may need accommodations (e.g., more time to process their peers comments, questions to be written and verbalized). Research should also further explore which students benefit from discourse-intensive instruction paying close attention to issues of power and participation. Prior research found links between students' socioeconomic status and participation in whole class discussions (Lubienski, 2000), thus it should not be assumed that these discourse-focused teaching practices are best for all students in all contexts.

Appendix A: IRB Consent Form

Project Title	*Teacher Candidates learning trajectories in a post-baccalaureate teacher certification program*
Purpose of the Study	*This research is being conducted by Dana Grosser-Clarkson at the XXXX XXXXX, XXXXXX. We are inviting you to participate in this research project because you are a student enrolled in our post-baccalaureate preparation program and more specifically XXX XXX. The purpose of this research project is to explore teacher candidate's learning trajectories and how the methods courses supported or inhibited this growth.*

Procedures	*The procedures involve two levels of participation. The first level will require no additional work on your part. Participation would allow the researcher access to the following:*
	
	    all course assignments completed in XXX XXX and Methods II
	    all communications/comments via ELMS or email
	    all materials submitted for the edTPA
	
	    I consent to allowing the researcher access to my program submissions that are listed above.
	
	The second level of participation would require an additional classroom observation and two 30-minute interviews. The researcher will select approximately three participants for this case study. The pool of candidates who consent to this additional involvement will, in part, determine the selection criteria. Ideally, these criteria will capture similarities or differences, such as teaching assignments (e.g., 6th grade math, 8th grade Algebra), field placement, or post-baccalaureate program (i.e., XXX or XXXX). If chosen, you will be notified via email by mid-January. The observation and interview would take place during the spring at your field placement school. The interview questions will ask about the XXXX XXXX coursework and how it impacted your development as a teacher. These interviews will be audio recorded.
	
	    I consent to additional participation, which includes a classroom observation and two interviews.

	All audio and visual data from these sources will be transcribed and only the transcriptions will be used for research. Participation in this research will not impact your grade, because the researcher will not know who has consented until the final grades have been submitted. The assignments and communications of students who have consented will be compiled after the final grades are submitted.
Potential Risks and Discomforts	*There are no known risks from participating in this research study.*
Potential Benefits	*There are no direct benefits from participation in this research. We hope that, in the future, other people might benefit from this study through improved coursework and understanding of how teachers learn.*
Confidentiality	*Any potential loss of confidentiality will be minimized by deleting your name from the assignments and storing data on a password protected computer only accessible by the researcher. Any audio or visual recordings used will be transcribed to protect your identity and only the researcher will have access to these original data sources.* If we write a report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.
Right to Withdraw and Questions	Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify. If you decide to stop taking part in the study, if you have questions, concerns, or complaints, or if you need to report an injury related to the research, please contact the investigator: **Dana Grosser-Clarkson** **University of Maryland** **B0108 Cole Fieldhouse** **269-267-5008** **dgrosser@umd.edu**
Participant Rights	If you have questions about your rights as a research participant or wish to report a research-related injury, please contact:

	University of Maryland College Park **Institutional Review Board Office** **1204 Marie Mount Hall** **College Park, Maryland, 20742** **E-mail:** irb@umd.edu **Telephone: 301-405-0678** This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.
Statement of Consent	Your signature indicates that you are at least 18 years of age; you have read this consent form or have had it read to you; your questions have been answered to your satisfaction and you voluntarily agree to participate in this research study. You will receive a copy of this signed consent form. If you agree to participate, please sign your name below.
Signature and Date	**NAME OF PARTICIPANT** **[Please Print]**	
	SIGNATURE OF PARTICIPANT	
	DATE	

Appendix B: Case Study Selection Chart

Table 12
Round One Case Selection

Candidate	IRB Consent for Case Study	Participated in Methods I	I had no other evaluator role (i.e., supervision) with TC
#1- Meredith	Yes	Yes	Yes
#2-Jill	Yes	Yes	Yes
#3-Jennifer	Yes	Yes	Yes
#4-Jack	Yes	Yes	Yes
TC #5	Yes	Yes	No
TC #6	Yes	Yes	Yes
TC #7	No	No	No
TC #8	Yes	Yes	Yes
TC #9	No	No	Yes
TC #10	Yes	No	No
TC #11	Yes	Yes	Yes
TC #12	Yes	No	No
TC #13	No	No	Yes
TC #14	Yes	No	No
TC #15	Yes	Yes	Yes
TC #16	Yes	No	Yes

Table 13
Round Two and Final Case Selection

Candidate	Removal Reason	Selected
#1- Meredith		Selected
#2-Jill		Selected
#3-Jennifer		Selected as a case and data was analyzed; however, case was not written up due to spring completion issues
#4-Jack		Selected
TC #6	Fell behind in methods II coursework	-
TC #8	Classroom management/school context issues	-
TC #11	Classroom management/school context issues	-
TC #15	Fell behind in methods II coursework	-

Appendix C: Audio Analysis Assignment #1

In this assignment you will be applying the concepts and practices that we explored so far in this course. First, you are being asked to familiarize yourself with the task (see below). Second, you will take on a student role and prepare yourself for acting accordingly with others who have the same student role. Next, you will work in partners to take on the role of the student and the teacher in two separate segments, each 5 minutes in duration. The overarching goal of this assignment is to create an opportunity for teachers to think on their feet. As the teacher your goal in this assignment is to make sense of the student's work and their thinking and to engage in productive questioning practices. In addition, you will be asked to reflect on this process.

For this assignment, we ask that you address the following.
- Explain (in your own words) the student's thinking/ their wrong ideas
- Identify the questions that you posed (copy down verbatim from the audio recording)
- Explain what your goal was for each of the questions that you asked
- Reflect back on your questions, articulate what you learned from examining your questions and suggest refined questions

There is no required format or length for your response. You are required to submit both your response and the audio file.

Jan practiced piano each day after school. The chart shows how much she practiced each day.

Jan's Piano Practice Schedule

Day	Practice Time
Monday	$\frac{1}{4}$ hour
Tuesday	$\frac{1}{2}$ hour
Wednesday	$\frac{3}{4}$ hour
Thursday	$\frac{1}{2}$ hour
Friday	none

How much time did Jan spend practicing Monday through Friday?

Show your work using words, numbers, or pictures.

Jan practiced piano each day after school. The chart shows how much she practiced each day.

Jan's Piano Practice Schedule

Day	Practice Time
Monday	$\frac{1}{4}$ hour
Tuesday	$\frac{1}{2}$ hour
Wednesday	$\frac{3}{4}$ hour
Thursday	$\frac{1}{2}$ hour
Friday	none

How much time did Jan spend practicing Monday through Friday?

Show your work using words, numbers, or pictures.

```
  2 5min
  3 0
  4 5
  3 0
    0
─────────
 1 3 0min
```

She practiced 130 minutes which is equal to 2h and 10min

How much time did Jan spend practicing from Monday through Friday?

2 hours, 10 minutes / 130 min.

Jan practiced piano each day after school. The chart shows how much she practiced each day.

Jan's Piano Practice Schedule

Day	Practice Time
Monday	$\frac{1}{4}$ hour
Tuesday	$\frac{1}{2}$ hour
Wednesday	$\frac{3}{4}$ hour
Thursday	$\frac{1}{2}$ hour
Friday	none

How much time did Jan spend practicing Monday through Friday?

Show your work using words, numbers, or pictures.

$\frac{1}{2} + \frac{1}{2} = 1$ $\frac{4}{4} = \frac{4}{12}$

$\frac{1}{4} + \frac{3}{4} = \frac{4}{12}$ $\frac{4}{4} = \frac{4}{12}$

She practised $1\frac{4}{12}$ of an hour on monday through friday.

How much time did Jan spend practicing from Monday through Friday?

$\frac{4}{12}$ of mondy through friday.

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Appendix D: Video Analysis Assignment #1

During the last week of class you will deliver your lesson plan (about 30-35 minutes) to your peers. The lesson delivery will be videotaped for your review and you will also receive anonymous feedback from your peers. This assignment will require that you review your videotaped lesson and peer feedback to analyze the delivery of your lesson plan. In no more than 3 single-spaced pages, please elaborate on the following prompts:

1. Explain how you monitored (listened and responded to), selected, and sequenced the student work for productive classroom discussion.
2. Explain how you elicited students' mathematical thinking (by asking questions and facilitating discourse) to help develop understanding of the lesson objective.
   a. Find one instance in the video (and provide time stamps) where you feel you could have improved the classroom discourse by asking a different question or doing something different. Explain why you think this would have led to a more productive outcome.
3. What changes would you make to your lesson plan to better support students learning of the lesson objective?

Lastly, don't forget to share your revised lesson plan with your peers on our Google Drive.

Analysis of Lesson Plan Delivery Scoring Rubric

Criteria	1-points	2 points	3 points
Analysis of how you monitored, selected, and sequenced student work for productive classroom discussion	Need to increase depth of analysis of monitoring, selecting, and sequencing student work	Satisfactory analysis of monitoring, selecting, and sequencing student work	Exemplary analysis of monitoring, selecting, and sequencing student work
Analysis of how questioning was utilized AND what you learned about student thinking	Need to increase depth of analysis of questioning practices or be more specific about student thinking	Satisfactory analysis of how questioning was utilized but did not include what you learned about student thinking.	Exemplary analysis of how questioning was utilized AND included what you learned about student thinking
Analysis of one specific scenario AND suggestions for improvement.	Provides one instance (with time stamps) but needs to increase depth of analysis	Satisfactory provides specific instance (with time stamps) but was not specific about how it could be improved	Exemplary job providing specific instance (with time stamps) AND how they could be improved by a different question or teacher move.
Overall lesson plan alterations	Need to rethink additional alternations and/or include more details of how lesson could be improved.	Satisfactorily addresses additional alternations that could improve the lesson.	Exemplary job addressing additional alternations that could improve the lesson.

Appendix E: Audio Analysis Assignment #2

You will be asked to audio-record your teaching twice this semester. The first recording will take place this week. We ask that you audio-record a 10-15 minute segment that provides an example of your classroom discourse. It may be easiest to record an entire class period and then to identify a continuous segment to use.

The overarching goal of this assignment is to create an opportunity for you to reflect on your questioning practices. Supporting productive classroom discourse is challenging and it is a skill that requires practice. We do not expect you to have mastered this skill, so we will not be evaluating you on the actual discourse during the segment. We are more interested in the way in which you are able to reflect on your interactions with students, so that you can improve your questioning and support productive classroom discourse. We ask that you do the following:

- Transcribe the questions that you pose during the 10-15 minute segment. You do not need to transcribe the students' responses.
- Explain what your goal was for each of the questions that you asked.
- Reflect back on your questions and articulate what you learned about students' thinking.
- Suggest refined questions and explain how/why they are an improvement.

There is no required format or length for your response.   You are required to submit both your response and the audio file through ELMS. If you have difficulties submitting, you can email us the word document and upload the audio file to ELMS.

Criteria	1 point	2 points	3 points	4 points	5 points
Explain what your goal was for each of the questions that you asked	Need to make significant improvements to be clearer as to why you asked each of the questions.	Need to make some improvements to be clearer as to why you asked each of the questions.	Need to make minor improvements to be clearer as to why you asked each of the questions.	Clearly articulated why you asked each of the questions – describes what you hope to get from asking each of the questions.	Exceptional articulation of why you asked each of the questions.
Reflect back on your questions and articulate what you learned about student thinking	Need major improvements on reflecting on your questioning practices, and sharing what you learned.	Need improvements on reflecting on your questioning practices and sharing what you learned.	Satisfactory job reflecting on your questioning practices, and sharing what you learned.	Nice job reflecting on your questioning practices, and sharing what you learned.	Excellent job reflecting on your questioning practices, and sharing what you learned.
Suggest refined questions	Need major improvements on suggesting refinements to questions.	Need improvements on suggesting refinements to questions.	Satisfactory job on suggesting refinements to questions.	Nice job on refinements to questions.	Exceptional refinements to questions.

Appendix F: Audio Analysis Assignment #3

For the second audio analysis we ask that you audio-record an entire class period. The overarching goal of this assignment is to create an opportunity for you to reflect on your questioning practices and teaching moves. Supporting productive classroom discourse is challenging and it is a skill that requires practice. We do not expect you to have mastered this skill. Instead, we are interested in the way in which you are able to reflect on your interactions with students, so that you can improve your questioning and support productive classroom discourse. We ask that you do the following:

- Identify (with a time stamp) and transcribe three instances in the audio where you implemented one of the teaching moves (e.g., revoicing, using wait time, asking students to restate or apply someone else's reasoning) or questioning strategies (e.g., probing, generating discussion, linking, extending, focusing) identified in the Smith and Stein reading (Chapter 6). Explain what your goal was for each of the questions/moves that you identified.
- Identify and transcribe two instances in the audio where you feel you could have improved the classroom discourse if you had used one of the teaching moves or questioning strategies. Explain why you think this would have led to a more productive outcome.
- Reflect back on your questions or moves and explain what you learned about students' thinking.

There is no required format or length for your response. You are required to submit both your response and the audio file through ELMS.

Criteria	1 point	2 points	3 points	4 points	5 points
Explain what your goal was for each of the questions/moves that you identified	Need to make significant improvements to be clearer as to the goal behind each questions/move identified.	Need to make improvements to be clearer as to the goal behind each questions/move identified.	Need to make minor improvements to be clearer as to the goal behind each questions/move identified.	Clearly articulated the goal behind each question/move identified.	Exceptional articulation of the goal behind each question/move identified.
Suggest questions/moves that might have been more productive	Need major improvements identifying questions/moves they may be more productive.	Need improvement identifying questions/moves they may be more productive.	Satisfactory job identifying questions/moves they may be more productive.	Nice job identifying questions/moves they may be more productive.	Exceptional job identifying questions/moves they may be more productive.
Reflect back on your questions/moves and articulate what you learned about student thinking.	Need major improvements on reflecting on what you learned about student thinking.	Need improvements on reflecting on what you learned about student thinking.	Satisfactory job reflecting on what you learned about student thinking.	Nice job reflecting on what you learned about student thinking.	Excellent job reflecting on what you learned about student thinking.

Appendix G: Video Analysis Assignment #2

For this assignment you need to video record an entire lesson. From this video you will need to identify 1-2 video clips (unedited and continuous) totaling no more than 15 minutes that demonstrates "how you interact with students in a positive learning environment to develop conceptual understanding, procedural fluency, and mathematical reasoning and/or problem solving skills" (edTPA secondary handbook, 2013, p. 16). You will need to submit a written response to the following prompts in <u>no more than 5 single-spaced pages (including prompts)</u>. Some of the prompts and rubrics below are taken straight from the edTPA handbook.

Provide Background for your lesson
1. Identify the learning objective of this lesson.
2. Identify the common core standards and practices that are addressed in this lesson.
3. Identify the cognitive demand level (i.e., memorization, procedures without connections, procedures with connections, or doing mathematics) of the task or activity.

Promoting a Positive Learning Environment (Rubric 6)
4. "How did you demonstrate mutual respect for, rapport with, and responsiveness to students with varied needs and backgrounds, and challenge students to engage in learning?" (edTPA, p. 21). Use time stamps to refer to specific scenes.

Engaging Students in Learning (Rubric 7)
5. a: Explain how your instruction engaged students in developing
   • Conceptual understanding
   • Procedural fluency
   • Mathematical reasoning and/or problem solving skills
B: Describe how your instruction linked students' prior academic learning and personal, cultural, and community assets with new learning.

Deepening Student Learning during Instruction (Rubric 8)
4. A: Explain how you elicited and built on student responses to promote thinking and develop conceptual understanding, procedural fluency, and mathematical reasoning and/or problem solving skills.

Analyzing Teaching (Rubric 10)
5. A: What changes would you make to your instruction—for the whole class and/or students who need great support or challenge—to better support students learning of the central focus (e.g., missed opportunities)?
B: Why do you think these changes would improve student learning? Support your explanation with evidence of student learning and principles from theory/ and or research.

Appendix H: Semi-Structured First Interview Protocol

"As you may recall, I am interested in exploring teacher candidates' learning trajectories throughout the course of our post-baccalaureate program. You have been selected as one of my cases to explore more in-depth. So I am going to ask you a few questions regarding your experiences."

Methods I
1. How do you think you have progressed in your use of teachers questioning strategies and teacher discourse moves to elicit student thinking?
2. If you can recall, how did you think your peer interview in Methods I went? Were you able to elicit the student thinking? What were some of the challenges? Did you think this was a good learning experience?
3. If you can recall, how did your microteaching in Methods I go? Were you able to elicit the student thinking? What were some of the challenges? Did you think this was a good learning experience?
4. Do you remember any course readings or videos from Methods I that we read or watched that you felt helped you develop in your teacher questioning/moves?
5. Is there anything else from Methods I that you can remember that really impacted your teaching?
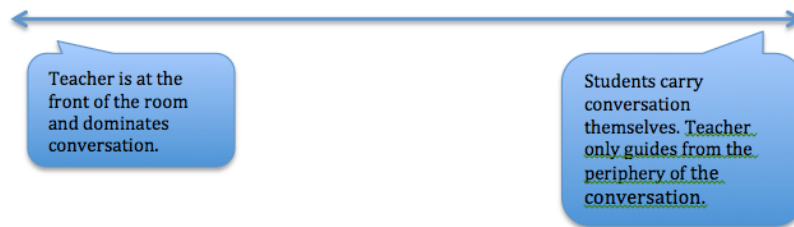
Methods II

6. If you can recall, how did you think your first audio analysis in Methods II went? Were you able to elicit the student thinking? What were some of the challenges? Did you think this was a good learning experience?
7. If you can recall, how did your second audio analysis in Methods II go? Were you able to elicit the student thinking? What were some of the challenges? Did you think this was a good learning experience?
8. If you can recall, how did your video analysis in Methods II go? Were you able to elicit the student thinking? What were some of the challenges? Did you think this was a good learning experience?
9. Do you remember any course readings or videos from Methods II that we read or watched that you felt helped you develop in your teacher questioning/moves?
10. I noticed that in your annotated bibliography that you rated _____ readings particularly high. Do you remember what it was about those readings that you felt was so helpful?
11. Is there anything else from Methods II that you can remember that really impacted your teaching?

Appendix I: Semi-Structured Second Interview Protocol

"Thank you for taking the time to meet me for this follow up interview. During the last interview we talked a lot about 457 and 651. I am going to ask you a few questions regarding your experience with the edTPA and the program more generally."

1. How did you think the edTPA went? Did you feel you were able to find a 15-minute clip that highlighted you eliciting student thinking?
2. Have you received any feedback yet? If so, was it helpful?
3. I noticed in your commentary that you cited _____. Did you find this reading particularly helpful
4. Looking back at your experiences throughout this program, are there other factors that you feel supported or prohibited your work toward improving your questioning strategies and teacher discourse moves?
5. What do you feel are your strengths when it comes to questioning strategies and teacher discourse moves?
6. What areas are you still focusing on for improvement? What do you plan to do to continue to work on these improvement areas?
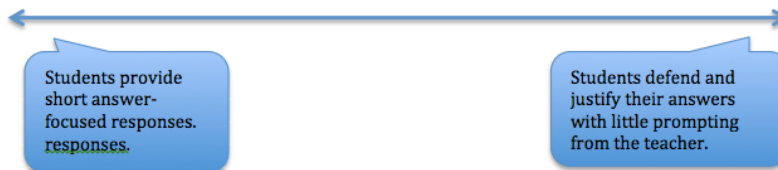7. Continuum of math classroom discourse

Teachers Role

Teacher is at the front of the room and dominates conversation.

Students carry conversation themselves. Teacher only guides from the periphery of the conversation.

Questioning

Teacher is the only questioner.

Student-to-student talk is student initiated.

Explaining Mathematical Thinking

Students provide short answer-focused responses. responses.

Students defend and justify their answers with little prompting from the teacher.

8. Show graphs and talk about Question Type 6 (i.e., making connection).

Appendix J: Overview of Pedagogies in Methods I by Session

Session	Topic	Components of Learning Cycle *Representation of Practice (RP),* *Approximation of Practice (AP), Enactment* *(E), Investigation of Practice (IP)*
1	The Nature of Mathematics	
2	Examining a standards-based educational climate	RP: Modeling (Mango Task)
3	Common Core State Standards for Mathematics	RP- Video SMP AP- Role-play Vignette SMP IP- Transcript Analysis
4	Standards for Mathematical Practice & Establishing Classroom Norms	RP-Modeling (Bag of Marbles) RP- Video SMP AP- Role-play Vignette SMP IP- Transcript Analysis
5	Lesson Planning	RP-Modeling (Midpoint Task) RP-Student work (Bag of Marbles)
6	Launching a High-level Task	RP-Video (Lipscomb) http://www.lipscomb.edu/ayers/video/play/25
7	Effective Questioning Practices	RP-Modeling (Fraction Task) RP-Student Work (Division) RP-Video (Lipscomb) RP-Video (Boaler & Humphries)
8	Eliciting and Responding to Students' Thinking	RP-Student work (Rectangle) AP-Role-play w/ Partner IP- Analyze Audio of Role-play
9	Orchestrating Productive Mathematics Discussions	RP-Modeling (Division Task) RP-Video (Lipscomb) RP-Video (Boaler & Humphries) RP-Student work (Bag of Marbles) RP-Student work (Marriage Problem)
10	Assessment	RP-Modeling (Punch Task) RP-Video (Lipscomb) AP-Lesson*Sketch* (Pizza Dough)
11	Tools and Technology	RP-Modeling (Proportional Task) RP-Video
12	Exploring Proportional Reasoning	RP-Modeling (Look-alike-Rectangles)
13-16	Presentations	AP-Lesson Enactment IP-Video 1-Analyze Lesson

Appendix K: Overview of Pedagogies Methods II by Session

Session	Topic	Components of Learning Cycle *Representation of Practice (RP), Approximation of Practice (AP), Enactment (E), Investigation of Practice (IP)*
1	Big Ideas of Algebra	E: Audio II IP: Audio II
2	The Role of Curriculum/ Task Selection	
3	Studying Instructional Materials	RP: Modeling (Tiling Task) AP: Fictional Dialogue for Tiling Task
4	Establishing Goals/ Objectives & Lesson Planning	RP: Modeling (Hexagon Task) AP: Lesson Study (Goals)
5	Anticipating Student Responses & Student Reasoning	RP: Modeling (Staircase Task) RP: Video (Annenberg Staircase Task) http://www.learner.org/courses/teachingmath/grades9_12/session_03/section_01_g.html IP: Transcript Analysis (Annenberg Staircase Task) AP: Lesson Study (Anticipate Student Responses)
6	Classroom Discourse	RP: Modeling (Sometimes/Always Never Task) RP: Video https://www.teachingchannel.org/videos/proportional-relationship-misconceptions-ccssmdc?utm_campaign=digest&utm_medium=email&utm_source=digest AP: Lesson Study (Collaborative Planning)
7	Assessment	AP: Lesson Study (Collaborative Planning)
8	Tools & Technology	RP: Table Tiling Task RP: Video (Teaching Channel-Tools) https://www.teachingchannel.org/videos/surface-area-lesson AP: Lesson Study (Collaborative Planning)
9	Equity & Access	E: Audio III IP: Audio III AP: Lesson Study (Collaborative Planning)
10	International Mathematics Education	RP: Video (TIMSS) http://www.timssvideo.com/66
11	Learning Disabilities	E: Video II IP: Video II
12	Lesson Study Focus	AP: Lesson Study (Collaborative Planning) E: Lesson Study
13	Teachers Matter	E: Audio record 8-10 min of practice in field placement IP: Analyze questions asked and student thinking
14-15	Group Presentations	IP: Lesson Study (Debrief)

Appendix L: Methods I Mathematical Task by Day

Day	Task	Source
1	Intersecting Lines/ Handshake Problem	http://www.nctm.org/Publications/Teaching-Children-Mathematics/Blog/The-Handshake-Problem/
2	Mangoes Task	http://illuminations.nctm.org/Lesson.aspx?id=1037
3	Statue of Liberty	http://figurethis.nctm.org/challenges/c61/challenge.htm
4	Bag of Marbles	Smith, M. S., Bill, V., & Hughes, E. K. (2008). Thinking through a lesson: Successfully implementing high-level tasks. *Mathematics Teaching in the Middle School, 14*(3), 132–138.
5	Triangle Mid-segments	Van de Walle, J. A., Bay-Williams, J. M, Lovin, L. H., & Karp, K. S, & (2014). *Teaching student-centered mathematics: Developmentally appropriate instruction for grades 6-8*. (2nd ed.). Boston, MA: Pearson.
6	Surprising Squares Task	**http://www.lipscomb.edu/uploads/video/woodard-task.pdf**
7	Fraction Subtraction Task	Rathouz, M., Rubenstein, R. (2009). Supporting PSTs' learning: A fraction operations task and its orchestration. AMTE Monograph 6- pp. 85-103.
8	Fraction Multiplication Task	[from Rick's materials]
9	Fraction Division Task	Boaler & Humphries?/ Van de Walle
	Marriage Problem	Kuper, E. G., & Kimani, P. M. (2013). Responding to Students' Work on a Rich Task. *Mathematics Teaching in the Middle School, 19*(3), 164–171.
10	Punch Problem	NCTM. (2000). Principles and Standards for School Mathematics. Connections Standard for Grades 6-8 (p. 275-278)
11	Burning Candles	Lim, K. H. (2009). Burning the candle at just one end: Using nonproportional examples helps students determine when proportional strategies apply. *Mathematics Teaching in the Middle School, 14*(8), 492–500.
12	Look alike rectangles	Van de Walle, J. A., Bay-Williams, J. M, Lovin, L. H., & Karp, K. S, & (2014). *Teaching student-centered mathematics: Developmentally appropriate instruction for grades 6-8*. (2nd ed.). Boston, MA: Pearson.

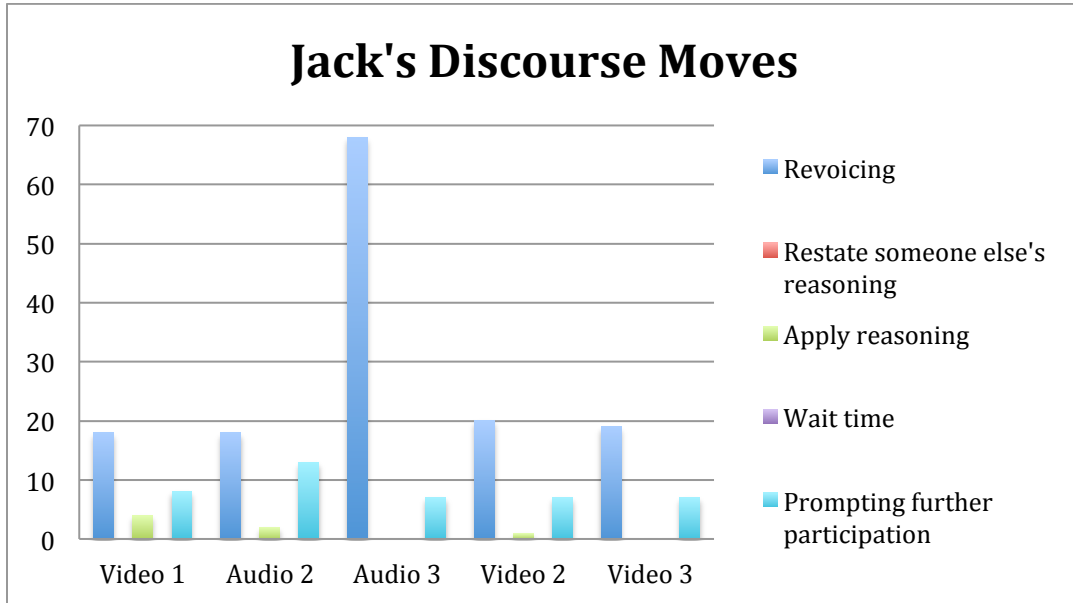**Appendix M: Methods II Mathematical Task by Day**

Day	Task	Source
1		
2		
3	Tiling Task	Smith & Stein (2011) -Case of Darcy Dunn- Tiling Task p. 22
4	Hexagon Task	Van de Walle (6th grade, High school, and teacher perspectives)
5	Staircase Task	http://www.learner.org/courses/teachingmath/grades9_12/session_03/section_01_b.html
6	Sometimes/Always Never	http://map.mathshell.org/lessons.php?unit=9210&collection=8
7		
8	Table Tiling Task	MARS: http://map.mathshell.org/tasks.php?unit=HE11&collection=9&redir=1
9		
10	(no in-class meeting)	
11		
12		
13	(Presentations)	

Appendix N: Articles/Tasks Enacted During Week 4 of Methods I

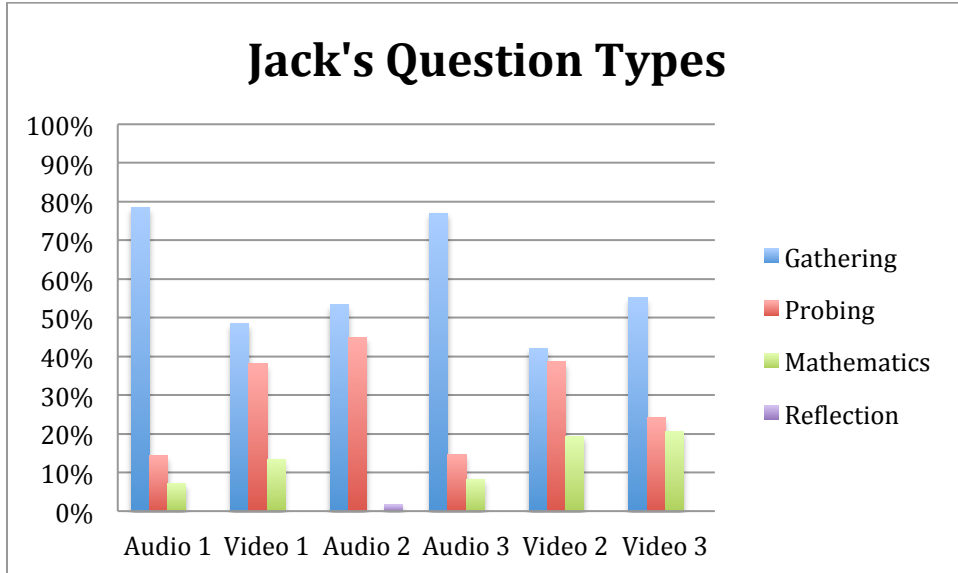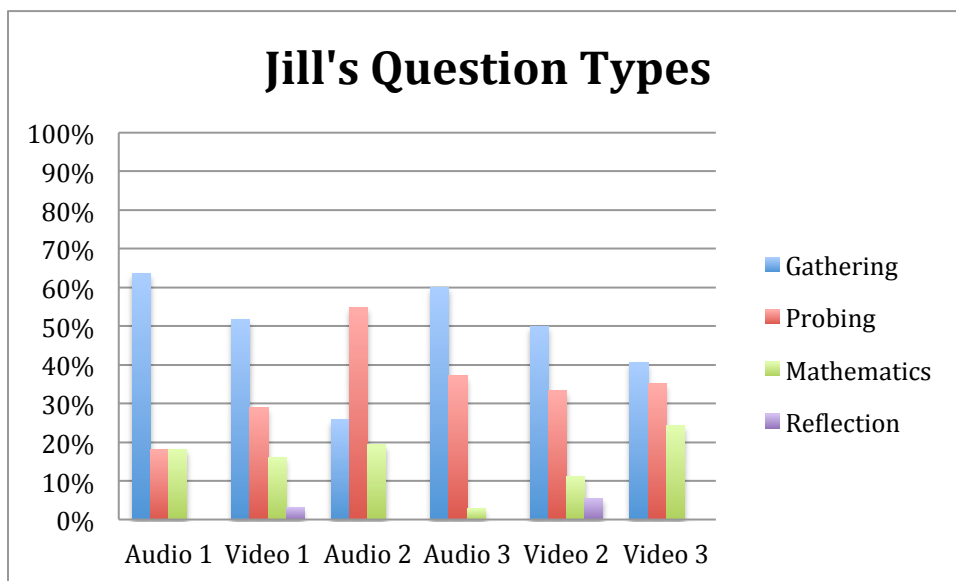| Session	Task	Sources
13	The Locker Problem	http://phschool.com/atschool/cmp2/active_math/site/Grade6/Locker/
	Fractions, Decimals, and Percents	Scaptura, C., Suh, J., & Mahaffey, G. (2007). Masterpieces to mathematics: Using art to teach fraction, decimal, and percent equivalents. *Mathematics Teaching in the Middle School, 13*(1), 24–28.
	Fair Sharing	Wilson, P. H., Edgington, C. P., Nguyen, K. H., Pescosolido, R. C., & Confrey, J. (2011). *Fractions: How to Share Fair. Mathematics Teaching in the Middle School, 17*(4), 230–236.
	Fraction Division **(Meredith)**	Kribs-Zaleta, C. M. (2008). Oranges, Posters, Ribbons, and Lemonade: Concrete Computational Strategies for Dividing Fractions. *Mathematics Teaching in the Middle School, 13*(8), 453–457.
14	Similarity	Cox, D. C., & Lo, J.-J. (2012). Discuss Similarity Using Visual Intuition. *Mathematics Teaching in the Middle School, 18(*1), 30–37
	Nets, Surface Area	Cherico, C. M. (2011). Geometry and the Design of Product Packaging. *Mathematics Teacher, 105*(3), 194–199.
	Surface Area of a Sphere **(Jill)**	Urich, J. A., & Sasse, E. A. (2011). *An Ap "peel" ing Activity. Mathematics Teacher, 105(*3), 189–193.
15	Modeling & Measurement	Imm, K. L., & Lorber, M. D. (2013). The Footprint Problem: A Pathway to Modeling. *Mathematics Teaching in the Middle School, 19*(1), 46–54
	Proportional Reasoning **(Jack)**	Markworth, K. A. (2012). Proportioning Cats and Rats. *Mathematics Teaching in the Middle School, 17,* 538–543.
	Measurement & Proportional	Zahner, W. C. (2012). ELLs and Group Work: It Can Be Done Well. *Mathematics Teaching in the Middle School, 18*(3), 156–164.
Day 16	Pattern Seeking	Lee, L., & Freiman, V. (2006). Developing algebraic thinking through pattern exploration. *Mathematics Teaching in the Middle School, 11*(9), 428.
	Patterns and Functions	Reeder, S. L., & Abshire, G. E. (2012). Talking about the Greek Cross. *Mathematics Teaching in the Middle School, 17*(9), 558–563.
	Painted Cube	Koellner, K., Pittman, M., & Frykholm, J. A. (2008). Talking generally or generally talking in an algebra classroom. *Mathematics Teaching in the Middle School, 14*(5), 304–310.

Jack's Discourse Moves

(Note: Audio 1 is not included since that was a one-on-one interview)

Jack's Question Types

Jill's Discourse Moves

Categories:
- Revoicing
- Restate someone else's reasoning
- Apply reasoning
- Wait time
- Prompting further participation

Jill's Question Types

Categories:
- Gathering
- Probing
- Mathematics
- Reflection
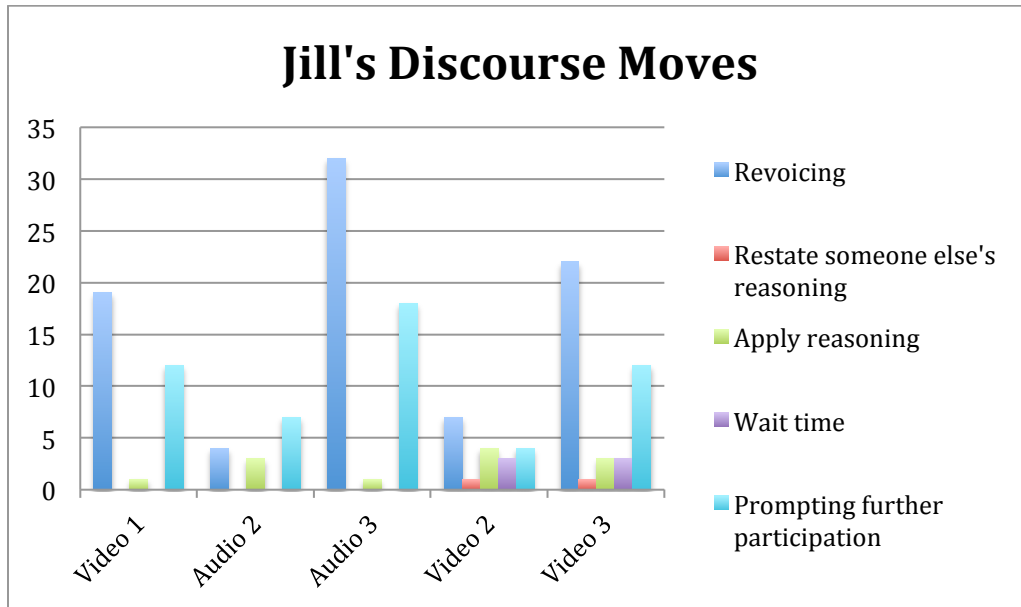
Appendix Q: Meredith's Discourse Moves and Question Types

Meredith's Discourse Moves

Legend:
- Revoicing
- Restate someone else's reasoning
- Apply reasoning
- Wait time
- Prompting further participation

X-axis: Video 1, Audio 2, Audio 3, Video 2, Video 3

Y-axis: 0 to 14

Meredith's Question Types

Legend:
- Gathering
- Probing
- Mathematics
- Reflection

X-axis: Audio 1, Video 1, Audio 2, Audio 3, Video 2, Video 3

Y-axis: 0% to 100%
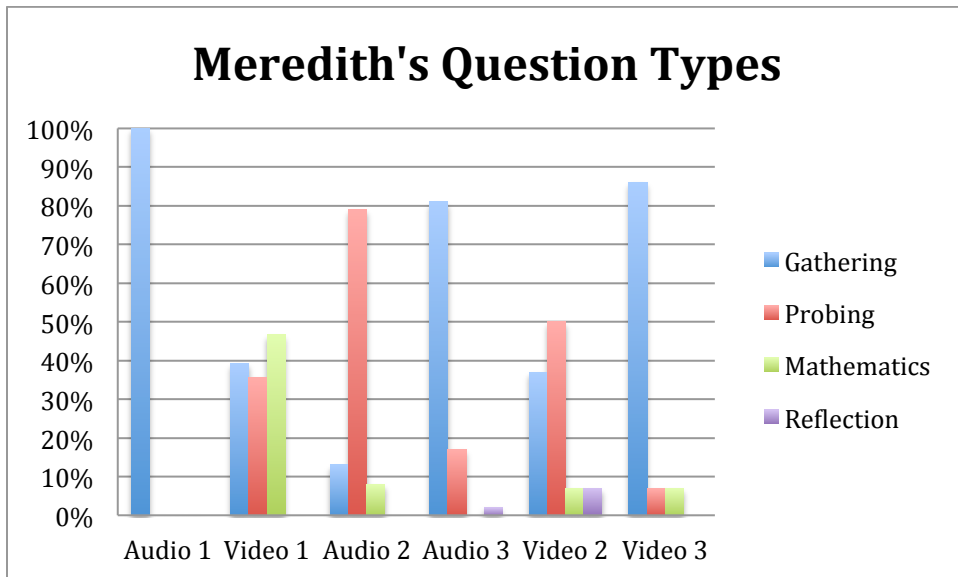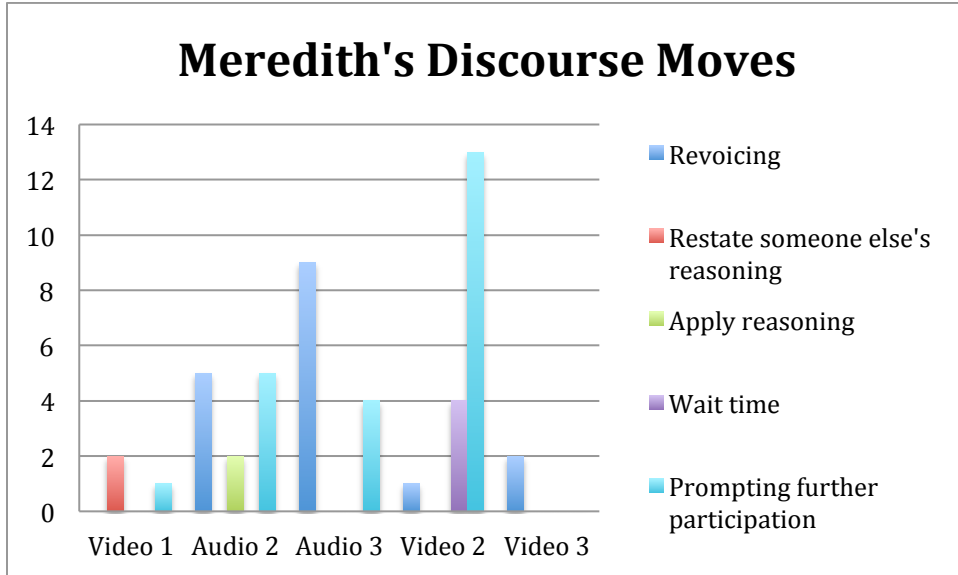
Appendix R: CCSSM Overview (Grades 6-8)

http://www.corestandards.org

Domain	6th Grade	7th Grade	8th Grade
Ratios & Proportional Relationships	Understand ratio concepts and use ratio reasoning to solve problems.	Analyze proportional relationships and use them to solve real-world and mathematical problems.	
The Number System	Apply and extend previous understandings of multiplication and division to divide fractions by fractions. Compute fluently with multi-digit numbers and find common factors and multiples. Apply and extend previous understandings of numbers to the system of rational numbers.	Apply and extend previous understandings of operations with fractions.	Know that there are numbers that are not rational, and approximate them by rational numbers.
Expressions and Equations	Apply and extend previous understandings of arithmetic to algebraic expressions. Reason about and solve one-variable equations and inequalities. Represent and analyze quantitative relationships between dependent and independent variables.	Use properties of operations to generate equivalent expressions. Solve real-life and mathematical problems using numerical and algebraic expressions and equations.	Work with radicals and integer exponents. Understand the connections between proportional relationships, lines, and linear equations. Analyze and solve linear equations and pairs of simultaneous linear equations.
Geometry	Solve real-world and mathematical problems involving area, surface area, and volume.	Draw construct, and describe geometrical figures and describe the relationships between them. Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.	Understand congruence and similarity using physical models, transparencies, or geometry software. Understand and apply the Pythagorean Theorem. Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.
Statistics & Probability	Develop understanding of statistical variability. Summarize and describe distributions.	Use random sampling to draw inferences about a population. Draw informal comparative inferences about two populations. Investigate chance processes and develop, use, and evaluate probability models.	Investigate patterns of association in bivariate data.
Functions			Define, evaluate, and compare functions. Use functions to model relationships between quantities.

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