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Preservice Teachers' Understandings Related to Language in the Mathematics Classroom

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Mathematics reforms are highlighting the important role that language plays in mathematics education. However, there remains a common misconception that mathematics is somehow language-free. This qualitative study explored 67 elementary preservice teachers' developing understandings about the role of language in the mathematics classroom based on their practicum experiences. Iterative, open-coding techniques were used to analyze mentor teacher advice and preservice teachers' observations of mentor teachers teaching a mathematics lesson. The tool helped focus preservice teachers' attention on language in the mathematics classrooms. Implications are identified for mentor and preservice teachers' knowledge and skill development toward linguistically responsive teaching practices.

Keywords: Bilingual, multilingual, and multicultural education, elementary education, teaching

Introduction

Increasingly, mathematics standards are highlighting the role that language plays in mathematics teaching and learning (e.g., National Council of Teachers of Mathematics (NCTM), 2010, 2014; National Governor's Association Center for Best Practices & Council of Chief School Officers, 2010). For example, the third Mathematical Practice in the Common Core State Standards advises that students should be able to "justify their conclusions, communicate them to others, and respond to the arguments of others" (National Governor's Association Center for Best Practices & Council of Chief School Officers, 2010). This means that students are progressively being asked to use language in a

variety of ways, i.e., speaking, listening, reading, writing, and representing, in order to increase and demonstrate their mathematical understandings.

Despite these increased expectations, content teachers may not receive focused preparation related to students' language development. This lack of preparation can be particularly challenging for teachers of mathematics because there is a common misconception that math is "language-free" (Aguirre & Bunch, 2012). For example, it has been found that preservice teachers often consider mathematics to be less language intensive than other subjects and may use tasks that have unrealistically high language demands (Bunch, Aguirre, & Téllez, 2015). In order to better prepare content teachers, Lucas and colleagues (2008, 2013) have outlined the orientations, knowledge, and pedagogical skills that teachers need in order to attend to students' language development. This study focuses on one strand of this work - the skill of "identifying classroom language demands of particular disciplines" (Lucas & Villegas, 2013, p. 103). This is an important skill for all mathematics teachers to develop in order to enact instruction that builds students' mathematical language *and* content knowledge.

However, there remains much to be learned about what factors shape preservice teachers' developing understandings related to language in mathematics teaching and learning during their teacher preparation programs. This development takes place over an extended period of time and in differing contexts. For example, preservice teachers may begin learning about mathematical language demands during their coursework. Then, they revisit these understandings during conversations with and observations of their mentor teachers in their practicum placement, and they finally enact these understandings in their own practice. Therefore, this study was designed to explore how preservice teachers come to understand language in mathematics during their field-based practicum in an effort to better inform teacher preparation coursework and practicum relationships. Specifically, this study was guided by the following research questions: (1) What types of advice do preservice teachers receive from their mentor teachers related to language in mathematics teaching and learning, and (2) What language demands do preservice teachers notice during a mathematics lesson in their field placement classroom?

Conceptual Framework

Attending to the role of language in mathematics is important as it has been found that children's language skills have a complex and intertwined relationship with their mathematical skills (Purpura & Ganley, 2014). In education, the role of language in mathematics teaching and learning has been conceptualized through three perspectives: the lexicon perspective, the register perspective, and the situated-sociocultural perspective (Moschkovich, 2002). The lexicon perspective focuses primarily on vocabulary acquisition, and emphasizes

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the importance of students learning mathematics vocabulary to decode and solve word problems (Dale & Cuevas, 1987; Institute of Education Sciences, 2014; Mestre, 1988; Rubenstein, 1996). In alignment with the lexicon perspective, teachers are encouraged to explicitly teach mathematical vocabulary (Dale & Cuevas, 1987; Institute of Education Sciences, 2014). However, it has been found that teachers may have limited knowledge of how to effectively teach mathematical vocabulary to students (Institute of Education Sciences, 2014).

The register perspective focuses on the multiple meanings of words in everyday life and mathematics (Schleppergrell, 2007). For example, the word *share* has a much more precise meaning in a mathematical word problem than it may have in less formal everyday conversation. In alignment with the register perspective, teachers are encouraged to teach students the components of the mathematical register so that students will be able to understand and communicate in a mathematics community. These components include symbols, oral language, written language, and visuals such as graphs (Schleppergrell, 2007). To support students, particularly bi/multilingual students, in acquiring the everyday and mathematical registers, teachers can use cognates, strategically move between registers, explain unfamiliar terminology, and use mathematical terms consistently (Hernandez, 1999; Khisty & Viego, 1999; Lager, 2006; Lemke, 2003).

Finally, the situated-sociocultural perspective combines and builds upon the lexicon and register perspectives to explore how bi/multilingual students use everyday and mathematical discourses in order to communicate and construct meaning in mathematical discourse communities (Moschkovich, 2002). In alignment with the situated sociocultural perspective, teachers can enact teaching moves designed to scaffold student engagement in the discourse community. These moves include: explicitly teaching students how to listen and respond, asking students to clarify their responses, revoicing student ideas, and using visuals (Moschkovich, 1999; Turner, Drake, McDuffie, Aguirre, Bartell, & Foote, 2012). Moschkovich (2015) extended the situated-sociocultural framework by identifying the knowledge bases that students need to be able to participate fully in mathematics classrooms. Pertinent to this study, these knowledge bases include modes of communication as well as discourse practices to communicate and engage in mathematical discussions. Moreover, Moschkovich (2015) argued that teachers of bi/multilingual students should move beyond "the static meaning of words supplied by the teacher or a textbook" (pg. 59) to a community where mathematical meaning is "situated, negotiated, and grounded in activity" (p. 59). In other words, it is not enough for teachers to supply definitions of mathematical terminology for students to repeat. Rather, teachers and students must actively engage in co-constructing the meaning of mathematical terminology and language forms through authentic mathematical discussion.

Taken together, these three perspectives highlight the need for teachers to attend to the language demands present in mathematics to better support student learning. In alignment with this aim, Lucas and Villegas (2013) argue that teachers need to develop "skills for determining the linguistic features of academic subjects and activities" (p. 101). In mathematics education, Aguirre and Bunch (2012) suggest that teachers should explore the language demands present in mathematics lessons through five modalities: reading, listening, speaking, writing, and representing. For example, students might be expected to read mathematical tasks and word problems, listen to their teachers and peers' explanations, explain and defend their solution strategies verbally, and write out or represent their solution strategies and thinking. In Aguirre and Bunch's (2012) conceptualization, representing is at the center of the modalities because it encompasses both the *process* and *product* of mathematical learning (NCTM, 2010, 2014). Specifically, mathematical representation refers to how students conceptualize mathematical concepts and relationships both internally as well as how they demonstrate this understanding externally (NCTM, 2010, 2014). In demonstrating their understanding, students often draw upon the other four modalities (e.g., verbally, graphically or visually explaining and defending one's thinking). Moreover, internal representations impact how and what students hear when listening to the ideas of others (NCTM, 2010, 2014).

Despite the important role that language plays in mathematics teaching and learning, preservice teachers may have limited knowledge of mathematical language demands and how these demands can impact their instruction and student learning (Bunch, Aguirre, & Téllez, 2015). Further, preservice teachers enter preparation programs with little knowledge of the supports that students, and particularly bi/multilingual students, may require when learning mathematics (Chval & Pinnow, 2010). For example, some preservice teachers may value building upon students' home language and emphasizing discourse practices, while others may focus narrowly on vocabulary acquisition, in alignment with a lexicon perspective (Turner et al., 2012). Given these documented challenges, I have focused this study on how preservice teachers develop their knowledge of mathematical language demands during their teacher preparation program. I specifically explore the advice that preservice teachers received from their mentor teachers related to language in mathematics as well as the language demands that preservice teachers notice when observing their mentor teacher's mathematical instruction; therefore, I now turn to these research bases.

Mentor Teacher Advice

Teacher education programs include time in field-based practicum classrooms which allows preservice teachers to learn from mentor teachers as well as implement the knowledge that they are learning in their teacher

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preparation program. The advice that preservice teachers receive from mentor teachers can shape preservice teachers' developing professional knowledge (Rodesiler & Tripp, 2012). In these collaborations, mentor teachers can provide a variety of advice, from active to reactive and directive to non-directive (Hennissen, Crasborn, Brouwer, Korthagen, & Bergen, 2008). However, it has been found that mentor teachers' advice often tends to focus more generally on classroom management and instruction, rather than explicitly advising preservice teachers about the actual students in the classroom or giving advice about how to develop content-specific instructional strategies (Coulon, 1994; Strong & Barron, 2004).

From the preservice teacher perspective, Hennissen and colleagues (2011) found that preservice teachers valued advice that gave emotional support or task assistance. Specifically, preservice teachers perceived that when mentor teachers summarized content, showed attentive behavior, shared positive opinions, summarized feelings, or gave information they were being emotionally supportive. While mentor teachers' requests for concrete explanations of instruction, help in identifying alternative forms of pedagogy, and sharing of information were perceived as being supportive of task design and implementation (Hennissen et al., 2011). Hennissen and colleagues (2011) contend that these findings illustrate the impact that mentor teacher professional development can have on preservice teachers as well as the types of mentoring skills that preservice teachers find most beneficial.

One potential challenge for mentor teachers is their need to balance their mentoring of a preservice teacher while still attending to their primary goal of the learning of their own students in the classroom (Edwards & Collison, 1996; Edwards & Protheroe, 2004). This tension can contribute to a complex relationship where mentor teachers are navigating the needs of their students first and the development of their preservice teacher second. Therefore, preservice teachers often have to intentionally elicit mentor teachers' advice and knowledge (Dunn & Taylor, 1993; Zanting, Verloop, & Vermunt, 2003). Therefore, some teacher educators have suggested that preservice teachers should be given tools to stimulate conversations and knowledge seeking moments from their mentor teachers in order to support their learning to teach journey (e.g., Zanting et al., 2003). Therefore, this study was designed to explicitly elicit mentor teacher advice and focus preservice teacher noticing on the role of language during their mentor teacher's mathematics instruction.

Teacher Noticing

In addition to exploring mentor teacher advice, I used a teacher noticing framework to unpack how preservice teachers understood mathematical language demands during observations of their mentor teacher's instruction. Education scholars have proposed noticing frameworks to explore how individuals make

meaning from what they see in their environment (e.g., Goodwin, 1994; Jacobs, Lamb, & Philipp, 2010; Jacobs, Lamb, Philipp, & Schappelle, 2011; Santagata, Zannoni, & Stigler, 2007; Sherin & van Es, 2009). Across the various framings of noticing, one commonality is that teacher noticing focuses on the attention that teachers give to actions in the classroom as well as their decision-making based on this attention. For example, Goodwin's (1994) concept of *professional vision to reform teaching*, focused on teachers' ability to notice features of one's practice in an effort to improve (Goodwin, 1994; Sherin, 2001). van Es and Sherin (2008) built upon Goodwin's (1994) framework to develop their own noticing framework that they used during "video clubs" where teachers watched and unpacked videos of their own classroom instruction. In their framework, the process of learning to notice included: (1) identifying notable aspects of a classroom situation, (2) using professional knowledge to reason about the classroom interactions and learning, and (3) making connections between the specific classroom context and broader aspects of teaching and learning (van Es & Sherin, 2008).

Building upon this work, Jacobs and colleagues created their framework for *professional noticing of children's mathematical thinking* (Jacobs et al., 2010, 2011). The framework included the following phases for teachers: (1) *attend* to children's mathematical thinking to ascertain patterns of understanding, and particularly the mathematics involved in children's strategies; (2) *interpret* children's mathematical thinking based on what teachers actually see in children's work; and (3) *decide how to respond* based on this interpretation and research on children's mathematical progressions (Jacobs et al., 2010, 2011). The three noticing skills are more underdeveloped in preservice teachers than in inservice teachers; therefore, professional noticing skills should be intentionally developed in preservice teachers (Jacobs et al., 2010).

Noticing skills can be developed over time through careful attention to professional development, teacher practice, and reflection (Jacobs et al., 2010; Star & Strickland, 2007; van Es & Sherin, 2008). For example, teachers can shift what they notice like moving from focusing on teacher actions to student understandings. Moreover, teachers can develop how they reason about what they notice. For example, shifting from evaluative comments of teacher actions to using evidence to interpret teacher actions and identify strategies that could move a teacher's practice forward (Sherin & Han, 2004; van Es & Sherin, 2008). Importantly, teachers can apply their understanding from these individual moments of noticing to their future classroom practice (Sherin & van Es, 2008).

While much of this work has focused on teachers' noticing of children's mathematical thinking (e.g., Jacobs et al., 2010, 2011; van Es & Sherin 2008), I believe that the noticing framework can be used to explore preservice teachers' noticing of language demands in mathematics. Specifically, the noticing

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framework can be used to explore which of the language demands preservice teachers *attend* to when observing a mathematics lesson as well as how they *interpret* this demand in relation to mathematics teaching and learning.

Methodology

In the following section, I provide methodological details about the context, participants, data collection tools, and data analysis techniques for this study.

Context

This qualitative study was implemented in three elementary mathematics methods courses that I taught over the course of one academic year to three cohort groups of preservice teachers. As background to this study, preservice teachers were introduced to the concept of language demands in mathematics teaching and learning at the start of the course. In class, we then watched two videos of mathematics lessons and used a version of Aguirre and Bunch's (2012) Language Demands in Mathematics Lesson (LDML) tool to identify the language demands present. Preservice teachers shared their noticing with small groups before having a whole group discussion where they identified the language demands they noticed, interpreted the role of the language demand in the mathematics lesson, and reflected on how this demand shaped student learning. These course activities were designed to lay the foundation for the field-based practicum experience. As part of their teacher education sequence, preservice teachers were required to complete a twice-weekly full day field-based practicum in local elementary schools. While the majority of the preservice teachers (49 total) had clinical field placements in monolingual English-speaking classrooms, some preservice teachers (18 total) had practicum placements in dual language programs.

Participants

Of the total 67 participants, 38 preservice teachers identified as monolingual English speakers and 29 identified as bi/multilingual. Racially, 34 participants identified as White, 23 identified as Latinx, 10 identified as Asian, and 1 identified as Native Indian. Moreover, 53 participants identified as women and 14 identified as men.

Data Sources

In the mathematics methods course where this study took place, there was an emphasis on teaching children with developmentally appropriate and culturally and linguistically responsive pedagogical practices (e.g., Carpenter, Fennema, & Franke, 1996; Turner et al., 2012). Therefore, I developed a field-based assignment entitled "Language Demands in the Mathematics Classroom" to

encourage reflection on the role of language in mathematics teaching and learning. This assignment became the data collection tool for this study. Specifically, the tool consisted of three parts: (1) elicit mentor teacher advice about language in mathematics teaching and learning, (2) observe a mathematics lesson to document the language demands present from the students' point of view (i.e., speaking, listening, reading, writing, and representing) (Aguirre & Bunch, 2012), and (3) reflect on the role of language in mathematics based on the discussion with the mentor teacher and observations during the mathematics lesson.

For the mentor teacher discussion, I provided open-ended questions that preservice teachers could ask their mentor teachers. For example, what is the role of language in your mathematics planning, instruction, and/or assessment, or how do students use language in mathematics lessons? However, I encouraged preservice teachers to modify and add to these questions based on their own understandings of the content and their practicum classrooms. Based on reports of the interviews, all of the preservice teachers asked their mentor teachers the provided questions and added more context-specific questions or probes.

For the observations of a mathematics lesson, I provided a version of Aguirre and Bunch's (2012) LDML tool for preservice teachers to use when watching their mentor teacher teach a mathematics lesson. I instructed the preservice teachers to focus on how and when students spoke, listened, wrote, read, and represented during the lesson. Preservice teachers then constructed a narrative that described where in the lesson the demand was noticed, how the mentor teacher structured the demand, and what students were doing when the demand was noticed.

Finally, preservice teachers were asked to reflect on the following prompt: based on your conversation with your mentor teacher, your observation, and course content, what is the role of language in mathematics learning and teaching? This prompt was left intentionally broad to allow preservice teachers to reflect on the most personally salient aspects.

Data Analysis

Data analysis was multi-phased given the nature of my data collection tool. During preliminary analysis, I focused on coding and summarizing the data in order to identify themes relative to my research foci (Miles, Huberman, & Saldaña, 2014). I employed iterative coding techniques (Marshall & Rossman, 2014) to analyze the advice preservice teachers received regarding how, or even if, their mentor teachers attended to language in mathematics. I used a combination of etic and emic codes (Goulding, 2005). Examples of etic codes included: direct advice, indirect advice, advice focused on lexicon, advice focused on the mathematical register, advice focused on the situated sociocultural

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perspective. Examples of emic codes included: advice related to assessments and particularly high stakes testing or advice evidencing a deficit perspective about the role of language in mathematics.

During the second phase, I analyzed preservice teachers' reports on the lessons they observed. This allowed a tabulation of the frequency with which preservice teachers noticed the individual demands and where in the larger lesson sequence these demands occurred. To be clear, by design, this was not meant to be an analysis of all the language demands present in the mathematics lesson; rather, this analysis explored what types of language demands preservice teachers attended to in order to explore their developing noticing of language demands. During the final phase of analysis, I employed iterative open-coding techniques (Marshall & Rossman, 2014) to analyze preservice teachers' reflections on the role of language in the classroom. I coded for beliefs about the role of language in mathematics, specific pedagogical strategies related to language, and evidence of how the interview with their mentor teacher and/or their classroom observation was shaping their current thinking.

Findings

In the following, I present my findings related to advice that preservice teachers received from their mentor teachers, preservice teachers' noticing of language demands during a mathematic lesson taught by their mentor teacher, and preservice teachers' reflections on the role of language in mathematics.

Advice from Mentor Teachers related to Language in Mathematics

Initially, 48 preservice teachers reported that their mentor teachers expressed "reluctance" or "confusion" about the role of language in mathematics or "had no answer at first." After this initial confusion, the majority of mentor teachers focused on vocabulary in their advice for preservice teachers. Specifically, of the total 204 coded excerpts of mentor teacher advice, 166 of these excerpts evidenced a lexicon perspective (Dale & Cuevas, 1987; Institute of Education Sciences, 2014). For example, mentor teachers suggested using a variety of instructional strategies to support students' mathematical vocabulary development, including: front loading vocabulary, using visuals, associating movements with vocabulary words, having students choral repeat vocabulary words and definitions, posting anchor charts of vocabulary words, vocabulary journals "where the students can define and draw a picture of the word," and using vocabulary word banks that students could use with sentence frames to construct their answers.

The majority of these suggestions were indirect in nature as they did not focus on specific students or mathematical concepts that would benefit from these strategies. However, there were four exceptions to this pattern where mentor

teachers gave direct advice related to specific content. As one preservice teacher reported in his mentor teacher's words,

> 'Especially when one is going to introduce a new concept, it's important to check what math language the students already know and what new terminology I am going to use in my lesson.' According to the mentor, the students focus more on the terms rather than learning a concept if they don't know the meaning of those terms. He prefers to use different visuals to introduce new math terminology. For instance, he said that before introducing the concept of decimal, he put up 'the great wall of base ten' on a Math territory (wall) of our classroom. He also displayed the cards of terms written in words. (Such as 1/10= one tenths) along with corresponding visual on a base ten wall.

Here, the mentor teacher gave direct advice related to teaching the lexicon of decimal place values. Overall, when giving advice about how to implement a lexicon perspective in practice, mentor teacher advice was more indirect and offered general strategies that could seemingly be used for any mathematical content. In the few instances when direct advice was given, it focused on specific content lexicon rather than the language needs of specific students.

A smaller proportion of the excerpts, nine total, related to the *register* perspective (Schleppergrell, 2007). Mentor teachers focused on the multiple meanings of words in the everyday and mathematical registers, the structure of word problems, and how to support students in understanding symbolic notation in mathematics. In the first subset, two mentor teachers focused on the everyday and mathematical meanings of words. For example, one preservice teacher reported that her mentor teacher "tries to avoid language in questions that could be interpreted in a couple of different ways because of students' language backgrounds." While another preservice teacher reported that her mentor teacher said:

> As far as my planning, I read through what the lesson entails and I plan out what I'm going to say and [look for] when the word has multiple meanings. [For example], I ask the kids "what is the sum of three and four" and they're thinking "I want some" and so you're always thinking about antonyms, synonyms, homophones, and things like that… So, any word that can remotely be misunderstood we just talk about it. I ask "what does this mean" and I have them talk to their neighbor.

These mentor teachers focused on how mathematical and everyday words and phrases might be confusing for students who are still learning to differentiate between the two registers. To address these potential confusions, mentor teachers highlighted two strategies: anticipate potentially confusing vocabulary in order to

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avoid language that has multiple meanings, and give instructional time for students to discuss the language with a partner.

Another aspect of the register perspective relates to supporting students in making sense of the structure of word problems (Lager, 2006; Lemke, 2003). In this theme, four mentor teachers described their curriculum as having "a lot of wordy-word problems" or as "extremely wordy and with a lot of unnecessary vocabulary in them." One mentor teacher suggested simplifying the word problems by just giving the students the equation to solve, thereby lowering the cognitive demand for students. Another mentor teacher shared her strategy for helping students make sense of the structure of word problems as follows:

> We have practiced underlining what the problem is really asking, determining what's really happening in a given story problem and translating that into a math operation that needs to be done to solve the problem, communicating our strategy in equations and words, and answering in a complete sentence.

While these mentor teachers do highlight the role that lexicon plays in word problems, they also demonstrate a register perspective by focusing on how the structure of word problems, for example, having unnecessary information or using mathematical and everyday lexicon, impacts students' mathematical learning. As with the lexicon perspective, these excerpts included indirect, general advice that preservice teachers could seemingly implement with any content area or student. An exception to this can be seen in the previous excerpt related to the potential confusion between the words 'some' and 'sum' which evidenced a direct focus on a specific mathematical and everyday vocabulary term.

Turning to the situated sociocultural perspective (Moschkovich, 2002), 18 excerpts focused on privileging the role of discussion in advancing students' mathematical understandings. As one mentor teacher said, "it's perhaps more important that every student be able to speak about math and apply it to their own everyday life rather than remembering a list of vocabulary words." For example, one mentor teacher described an activity where she would open a math lesson by providing examples of the concept that students would be learning about and then having students discuss what they notice. The preservice teacher summarized her mentor teacher's advice as follows:

> This activity has allowed every student to participate in the conversation…some can say, "I noticed they are all fractions," or "I see a ratio," then someone with more experience might say, "I see equivalent fractions." It allows everyone to participate. Everyone has a chance to engage and you start to build that confidence. Even kids struggling with language they can say, "this is what I see".

While this mentor teacher provided an instructional strategy for encouraging student discourse that directly related to equivalent fractions, a specific mathematical concept, other mentor teachers provided more indirect advice that could be used for multiple concepts. For example, providing sentence frames, as one mentor teacher suggested, "use sentence frames when they critique their friend's strategy like: 'I respectfully disagree because…' and 'I agree with XXX because…'" Other suggested instructional strategies included using frequent turn and talk partner conversations during instruction and assigning group roles so that everyone has a specified way to contribute during group work. Interestingly, the majority of these excerpts referred to partner or small group discussions as a means of advancing student understanding and there were only four instances that referred to whole group mathematical discourse. Moreover, as with the lexicon and register perspectives, the advice given related to the situated-sociocultural perspective was more general and indirect except for the exception seen in the excerpt above. In other words, mentor teachers would suggest that discussion, particularly partner and small group discussion, was beneficial for student understanding but would not give concrete suggestions of how to implement this practice with specific students or specific mathematical concepts.

Preservice Teachers' Noticing of Language Demands during Observations

During observations, the most prevalent language demand noted across the data set was listening. Of the total 947 coded excerpts, 330 were instances where preservice teachers attended to students listening. Moreover, the majority of the instances, 254 total, involved students listening to the teacher's directions or instruction, while the remaining 76 excerpts were instances of students listening to their peers. These two contexts for listening are illustrated in the following excerpt:

> Students were listening to the teacher as she was asking questions and giving quick instructions and demonstration…Students were listening to each other as they were solving the problems. They listened as other student explained how to put cubes together to get their [tens].

With the teacher, students were asked to listen to instructions, questions, modeling, vocabulary definitions, and content instruction. With their peers, students were primarily asked to listen to peers explain their mathematical thinking for specific problems or provide definitions of key mathematical terminology. The moments where students listened to peers were primarily structured as partner or small group talk within the larger mathematical instruction. However, there where 12 excerpts in which students were encouraged to listen to each other during a whole group conversation about a mathematical concept.

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Furthermore, preservice teachers often attended to listening and speaking as interrelated demands for students. In the total 257 coded excerpts where students were asked to speak, the preservice teachers also noted a listening demand directly preceding or following this speaking demand, as seen in the following excerpt:

> Students were also sometimes asked to respond by speaking. During the mini-lesson and the activity, students had to listen to the teacher's prompting questions and respond to them. These teacher's prompting questions were especially demanding. An example was, "How many tens are in this number, 34."

In these classrooms, the listening excerpts often highlighted students listening to a teacher's instruction and then answering a question using a call and response method of instruction (Smitherman, 1977). This type of student-teacher interaction can be seen in the previous quote. However, there were 88 coded excerpts were preservice teachers noticed that their mentor teachers encouraged students to speak and listen to their peers during partner or small group discussions. Moreover, there were 12 instances where preservice teachers noticed that students were asked to speak to each other during whole group discussions about their mathematical thinking.

Preservice teachers attended less frequently to reading and writing demands for students during their observations. Preservice teachers noticed 156 instances where students were asked to read text. This could be reading text on the board that supported the teacher's verbal instruction, 97 instances, or reading individual problems written on a sheet of paper, 59 instances. All of the writing demands, 120 total, to which preservice teachers attended involved students individually writing down their answers to problem sets or tasks on a sheet of paper. This writing came in many forms from "writing an equation and finding an answer," to "writing out their answers in a complete sentence," to "drawing a picture and writing the answer with the correct units."

Overall, preservice teachers attended to the role of representing in mathematics lessons with less frequency than the other language demands of listening, speaking, reading, and writing. Preservice teachers noticed instances of students representing their thinking a total of 82 times. When unpacking their noticing of representing during these lessons, the majority of these preservice teachers referenced the use of manipulatives as evidence of students representing their thinking. For example, one preservice teacher said, "For representing, students were drawing their tens on the space provided. One student used cubes to demonstrate her work and provided her answer."

Other preservice teachers referenced students using base ten blocks, fraction kits, clocks, tables, tiles, diagrams and drawings to represent their

thinking. An exception to this pattern relates to students' work with the operations, and specifically multiplication and division. During observations, seven preservice teachers attended to how students were representing their solution strategies to multiplication or division problems as seen in the following excerpt:

> Students worked together and brainstormed several different ways of representing 3x5, which led us to a long discussion about the concept of multiplication itself. One of the students showed the equation on a number line and came to the conclusion that multiplication is simpler than she had thought, because it "is repeated addition!"

This excerpt discusses two ways a student represented their understandings related to the multiplication problem (i.e., number line and repeated addition). It also highlights how interrelated the language demands can be during actual instruction. In this case, one student was representing her thinking through writing and speaking while the rest of the class was listening to the student and reading her work on a number line.

This structured observation was designed to elicit what language demands preservice teachers attended to during an observation of a mathematics lesson. However, there was some evidence that seven preservice teachers began to interpret their noticing based on research and their own understandings of language demands in mathematics. In the following, one preservice teacher interprets her mentor teacher's strategy of using structured note taking for students in relation to students' language development:

> Ms. L adopts a direct teaching approach at the beginning of her lessons and then provides students with time to practice the strategies that they just learned about. She uses the document camera to show what she is writing or drawing in her notebook…I really like this idea of having matching numbered notebooks. It not only teaches students how to organize their thinking, but it gives ELs practice with three language modalities--two of which [writing and listening] situate themselves opposite each other on the language demands chart created by Aguirre and Bunch (2012). According to this chart, listening employs receptive oral language skills, and writing elicits productive literacy skills, while representing overlaps the two. So, it benefits students that have developed (or are developing) stronger oral skills first as well as students that have developed (or are developing) stronger literacy skills first.

In this excerpt, the preservice teacher attended to her mentor teacher's strategy of modeling how to take notes in a notebook while students copied down the teacher writing. The preservice teacher interpreted this strategy as benefiting students

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because students employ three demands - listening, representing, and writing. To support this interpretation, this preservice teacher drew upon Aguirre and Bunch's (2012) work to interpret this pedagogical strategy as benefiting students' oral and literacy skills.

It must be noted that while the protocol for this observation directed preservice teachers to record language demands for students, preservice teachers also attended to the mentor teachers' language use and, specifically, how the mentor teachers introduced vocabulary, 62 excerpts total. For example, one preservice teacher discussed how their mentor teacher spent the beginning of a math lesson discussing how "multiply and times really means groups of," while another preservice teacher reported that their mentor teacher focused on defining the word "parcel" for students so that they could complete the story problem of the day. This preservice teacher focus aligns with the previous section's findings that much of the mentor teachers' advice evidenced a lexicon perspective (Dale & Cuevas, 1987; Institute of Education Sciences, 2014). Overall, preservice teachers *attended* to all five language demands to varying degrees, with listening being the most common code for this data set followed by speaking, reading, writing, and representing respectively. Relatively few preservice teachers provided evidence of *interpreting* these observations based on research and their developing professional knowledge. However, many preservice teachers did reflect on their developing understandings related to language in mathematics as seen in the final findings section.

Preservice Teachers' Reflections on the Role of Language in Mathematics

There were 67 total excerpts where preservice teachers provided some insight into their current understandings of the role that language plays in mathematics teaching and learning. In these reflections, 23 excerpts focused on the fact that these preservice teachers had previously considered mathematics to be "language free" or "less language intensive than literacy" before talking with and observing their mentor teacher. After, these same preservice teachers reported that they were more aware of the role that language plays in mathematics teaching and learning. In the words of one preservice teacher:

> I, as a product of "language free math assumption" have never paid much attention or gave much thought to the role of language demands in the math classroom related to teaching, planning, assessing, or learning, therefore after this assignment it seemed like my eyes opened up.

Taken together, these preservice teachers reported being more aware of the role that language plays in their mathematics teaching and their students' learning. The majority of these reflections focused on generalized reflections related to how this knowledge could shape their own practice. As one preservice teacher shared,

"The role of language demands is crucial in ALL parts of teaching, as it impacts the teaching, planning, and assessing."

When giving specifics about the role of language in their mathematics teaching, many preservice teachers evidenced a lexicon perspective (Dale & Cuevas, 1987; Institute of Education Sciences, 2014). Of the total 67 excerpts, 23 focused on the role of vocabulary in mathematics teaching and learning. In one preservice teacher's words:

> Language has a huge role in the classroom when it comes to math. As my mentor teacher had mentioned before, many times we take it for granted that our students will know the vocabulary used in math problems, which will turn into half the students not knowing what to do many times. The other part, which is what I run into, is word problems that are just really confusing. Language can connect people and ideas together, but at the same time, if our students do not understand the language given, then it puts up barriers, which at worst, the students begin to doubt their intelligence and abilities.

In her reflection, this preservice teacher shared her current understandings based mainly on her mentor teacher's advice. Specifically, this preservice teacher focused on mathematical vocabulary and word problems as particularly salient when considering how to support students' linguistic development in mathematics. Moreover, she went on to state that vocabulary could potentially become a "barrier" for some students in her mathematics classes.

There were 15 coded excerpts where preservice teachers evidenced a situated sociocultural perspective (Moschkovich, 2002). As one preservice teacher shared, "When students are fluent in the language they have access to the whole wide world of mathematics. Mathematical discourse focuses on the students' ability to communicate, students need to clarify and justify their ideas and procedures." This comment is representative of the 15 excerpts in this subset of data in that all of the excerpts referred generally to engaging students in mathematical discussions, typically through explaining, defending, and justifying their solution strategies, without direct thoughts on how to plan, enact, or support these interactions. These generalized reflections echo much of the mentor teacher advice that was more indirect in nature. On one hand, these preservice teachers expressed a greater understanding related to the role of language in mathematics teaching and learning. While on the other hand, few of these preservice teachers had specific pedagogical plans to implement these developing understandings in their practice.

Discussion and Implications

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This study was designed to explore how field-based practicum experiences shape preservice teachers' understanding regarding the role of language in their mentor teacher's instruction. This adds to current conceptual models regarding the skills and knowledge teacher needs in order to be linguistically responsive teachers (e.g., Aguirre & Bunch, 2012; Lucas and Villegas, 2013) by exploring the actual understandings that preservice teachers develop about language demands as part of their preparatory experiences.

Mentor teachers' advice can shape preservice teachers' developing professional knowledge and skills (Rodesiler & Tripp, 2012). Therefore, teacher educators should intentionally elicit and unpack mentor teacher advice with preservice teachers (Dunn & Taylor, 1993; Zanting et al., 2003). In order to intentionally elicit advice from their mentor teacher, preservice teachers in this study interviewed their mentor teachers regarding their beliefs about the role language in mathematics teaching and learning. In alignment with this previous scholarship (e.g., Coulon, 1994; Strong & Barron, 2004), the majority of mentor teacher advice captured in this study was non-directive in nature. However, the goal of this study was not to classify the type of mentor teacher advice. Rather, the act of eliciting and unpacking mentor teacher advice opened space for preservice teachers to explore their mentor teachers' perspectives and the affordances and limitations of each perspective in relation to student learning.

The majority of mentor teacher advice evidenced a lexicon perspective, a finding that contradicts previous scholarly assertions that teachers may have limited knowledge of how to teach vocabulary to students (Institute of Education Sciences, 2014). This explicit attention to vocabulary in the mathematics classroom is a strong foundation that mathematics teacher educators can build upon and also provides an opportunity for teacher education programs to support mentor teachers. Since there was less evidence of a register perspective (Schleppergrell, 2007) or situated-sociocultural perspective (Moschkovich, 2002) in mentor teacher advice, teacher education programs could explore professional development opportunities for mentor teachers and preservice teachers to develop their knowledge and skills related to these under-represented perspectives.

During observations of their mentor teachers, preservice teachers noticed how students used language during the lesson, i.e., speaking, reading, writing, listening, and representing, as well as the language that their mentor teachers used when explaining tasks and mathematical content. Aguirre and Bunch's (2012) Language Demands in Mathematics Lessons (LDML) framework did support the preservice teachers in noticing the role that language played in these observed lessons as evidenced by their reflections. One limitation of this study is that the tool only collected what the preservice teachers attended to without a second observer for reliability. For example, preservice teachers reported that listening was the most common demand asked of students, and particularly listening to the

mentor teacher. This seems to indicate that the majority of these lessons were teacher centered, but it is not possible to say whether this is a true representation of the entire lesson or if this is a product of the preservice teachers' developing noticing skills. In other words, there could have been language demands present to which the preservice teachers did not attend. Therefore, more research is needed to explore whether or not preservice teachers overlooked other language demands during their observations because of their current stage of noticing or if these lessons were structured with little time for student interaction. However, a strength of the noticing framework (Jacobs et al., 2010, 2011; Sherin & van Es, 2009) is that it focuses on what teachers actually attend to in order to better attune their vision and interpretation of specific classroom events to improve student learning. As thus, this initial observational work could better inform teacher education coursework and discussions in an effort to attune preservice teachers' noticing of language demands in mathematics. Moreover, it reinforces the potential benefits of professional development sessions with mentor teachers *and* preservice teachers as they both could build upon what they are already doing and seeing in the classroom in order to create more engaging mathematical discourse communities. Ultimately, how teachers of mathematics structure and support the language demands in a mathematics classroom has to the potential to impact their students' mathematical and linguistic development.

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