Prospective Teachers' Conceptions about Language and Mathematics Regarding English Language Learners

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Little is understood about prospective teachers' conceptions regarding the mathematics education of English language learners (ELLs). This study examined prospective teachers' conceptions about language and mathematics while they investigated children's thinking in a mathematics for teaching[1] class. Findings show that participants thought teachers should help ELLs acquire mathematical language, which three participants saw as more than just vocabulary. All participants also thought it was important for children to express their mathematical understanding. However, two participants seemed to conceive of a unique way to express that understanding. These findings suggest that prospective teachers need to be critically exposed to literature regarding the mathematics instruction of ELLs earlier and more thoroughly through their teacher preparation coursework. Additionally prospective teachers will benefit from participating in experiences that focus on working with ELLs in mathematics classrooms.

Keywords: Mathematics teacher education; English language learners; children's thinking activities

Teachers in the United States (U.S.) cannot assume their students will have English as their primary language, nor that they will be fluent in English in order to participate as fully in the classroom as native English speakers (Khisty, 2001). The number of these students, referred to in this paper as English Language Learners (ELLs), is growing and there is an increased number currently mainstreamed into classrooms (Costa, McPhail, Smith, & Brisk, 2005). To wit, between 1979 and 2007 the number of students in the U.S. who spoke a language other than English at home increased from 9% to 20%. Moreover, as of 2008, about 5.3 million students were classified as ELLs (National Clearinghouse for English Language Acquisition; NCELA, 2010).

In response to the growing number of ELLs in the classroom, some researchers (e.g. Barnett-Clarke & Ramirez, 2004; Kersaint, Thompson, & Petkova, 2009) have compiled research-based strategies to model instruction that will benefit all children, but most importantly ELLs. One of the most notable is Sheltered English Instruction (SEI), an approach to teaching content in such a way that helps teachers "make concepts comprehensible while promoting the students' academic English language development" (Short & Echevarria 2004/2005, p.9). Although some U.S. teacher preparation programs are requiring courses focused on SEI, prospective teachers have historically received inadequate training to work with ELLs (Gay 2002; NCELA, 2010). Indeed, prospective teachers in the U.S., of which a majority are White, middle-class, and monolingual English speakers (Banks & Banks, 2000; Torok & Aguilar, 2000), come into teaching with limited cross-cultural background, knowledge, and experiences (Sleeter, 2001). Moreover, as alluded to at the

[1] A mathematics for teaching course is a mathematics content course designed specifically for teachers to investigate as learners the mathematics they will teach their students.

beginning of this paper, teachers are increasingly asked to teach students from backgrounds very different from their own.

While progress has been made in the last 15 years with teacher preparation programs beginning to focus more on social contexts, diversity, and multicultural education (Banks et al. 2005; Hollins & Guzman, 2005), there is still much to do. Indeed it does not seem that taking one course on multiculturalism (that may or may not include any mention of teaching and learning mathematics) will adequately prepare teachers to teach mathematics to the wide range of linguistically and culturally diverse children they will have in their classrooms (Hollins & Guzman, 2005; Sleeter, 2001). At best, the ideas and beliefs developed from one or two courses that focus on issues of diversity may be fragmented and may not assist teachers to develop their teaching practices for diverse learners (Milner, 2010).

A first step to help prospective teachers acquire the specialized knowledge needed to teach ELLs is for teacher educators to provide them opportunities to consider their conceptions (or their beliefs and knowledge) about language and mathematics. This step is essential, as prospective teachers have been found to have on ideological blinders in terms of teaching and learning due to their own cultural and educational experiences. These experiences have created entrenched beliefs and attitudes about themselves that are not easily relinquished (Ladson-Billings, 1994). One strategy in mathematics teacher education that has seen success in helping prospective teachers reconsider their beliefs and ideas regarding mathematics teaching and learning is the use of children's thinking activities[2]. In particular these types of activities have provided prospective teachers opportunities to unpack mathematical concepts while at the same time learn about student misconceptions and understand the need to learn mathematics at a more conceptual level (e.g. see Crespo & Nicol, 2006; Philipp, Thanheiser, & Clement, 2002).

In this article, prospective elementary teachers' conceptions while they completed children's thinking activities in a mathematics for teaching class are discussed. Specifically, the following question was investigated: When using children's thinking activities in a mathematics for teaching class, how do prospective teachers conceive of the role of language in teaching and learning mathematics?

Conceptual Framework

The design of the study and the analysis of the participants' conceptions were framed through a lens of mathematical communication as it relates to ELLs. The conceptual framework for this study, then, was comprised of areas of literature that focused on ELLs and (a) the language of mathematics and (b) prospective teachers' conceptions.

The Language of Mathematics

Several researchers (e.g. Cuevas, 1984; Moschkovich, 2000; 2002) have written about the mathematics register which consists of, among other things, meanings, phrases, structures, and modes of communicating "belonging to the natural language used in mathematics"

[2] The phrase *children's thinking activities* refers to activities that have been designed around children's mathematical thinking.

(Cuevas, 1984, p. 136) and exists separate to the everyday register (i.e. conversational language). Although registers are not disjoint with respect to the set of terminology used to describe particular concepts, the meanings attached to the terminology as well as the situational use of the terminology, phrases, structures, etc. may differ. For example, a table in everyday language is something on which you place objects; in mathematics it is a list of elements in a given set. In Spanish the word *cuarto* can mean 'quarter' or 'room' depending on the context in which it is used (Khisty, 1999; Moschkovich, 2000).

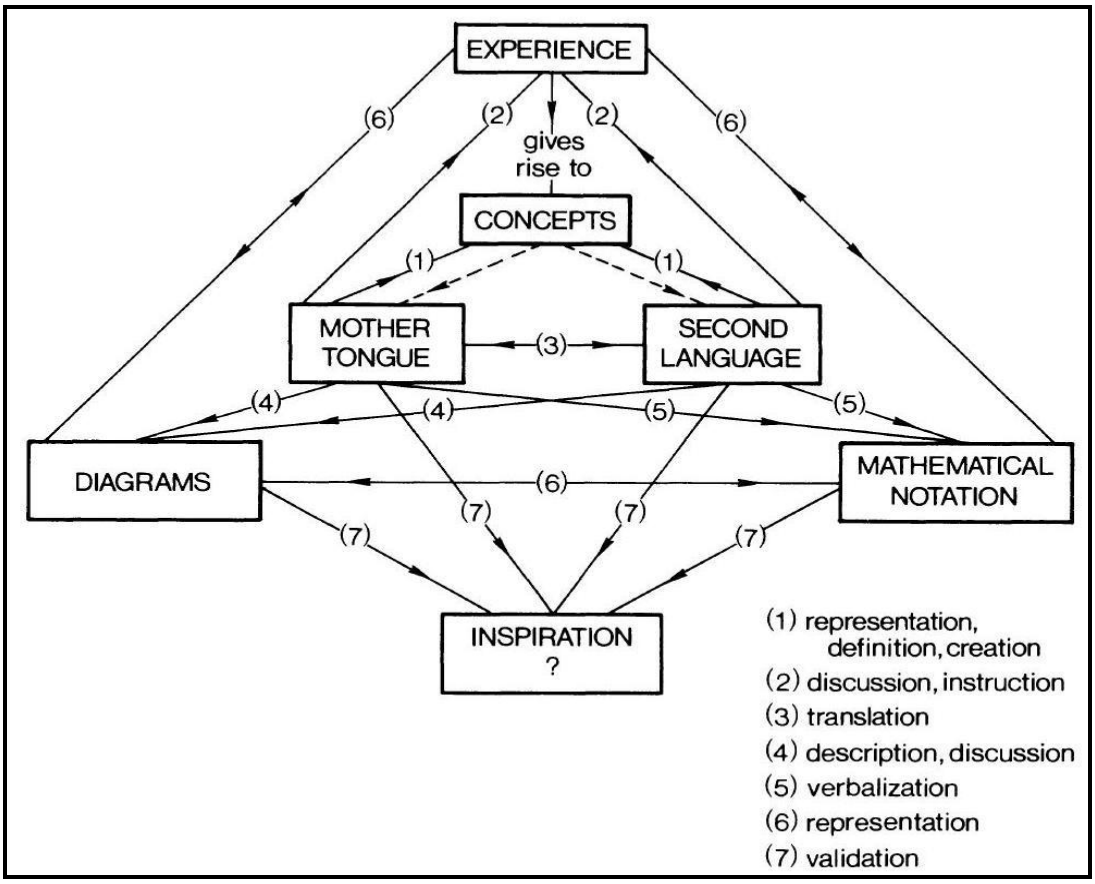

Figure 1. A model for considering the role of language in mathematical activity*.

***Note:** From "Mathematics Learning in English as a Second Language," by G. J. Cuevas, 1984, *Journal for Research in Mathematics Education*, *15*, p. 137. Copyright 1984 by the National Council of Teachers of Mathematics. Reprinted with permission.

Beyond the meanings of words/phrases used within and across registers, communication in mathematics is complex. It takes on many different forms including symbolic, linguistic, and pictorial (Schleppegrell, 2007). There are specific syntactic and semantic features such as the use of *if … then* structures and synonymous phrases such as "as old as" and "are the same age" (Anhalt, Fernandes, & Civil, 2007; Spanos, Rhodes, Dale, & Crandall, 1988) which are especially challenging for ELLs. In his model (see figure 1), Clark (1975, as cited in Cuevas, 1984) took note of the different linguistic activities in mathematics teaching and learning. These included discussion, verbalization, definition, and translation, all of which are a part of what it means to communicate mathematically (Khisty, 2001; Moschkovich, 2000). What is clear from the model is that both a student's primary language (L1) and secondary language (L2) are involved in all of the different linguistic activities.

Prospective Teachers' Conceptions

Content disciplines have only recently begun to acknowledge the importance of focusing on the instruction of ELLs during teacher preparation (Janzen, 2008). As such, few studies have investigated prospective teacher preparation as it relates to the instruction of ELLs (Zeichner, 2005). In mathematics, a review of the literature since 1990 found that although many researchers addressed the topic of preparing teachers to work with culturally diverse students, none focused specifically on issues related to preparing future teachers to work with ELLs (Janzen, 2008). Thus little is known about prospective teachers' conceptions of teaching mathematics to ELLs.

Based on other areas of research related to the teaching and learning of mathematics for ELLs, though, we can conjecture that prospective teachers may not be secure enough in their beliefs to challenge existing norms regarding mathematical discourse practices. In their research, Torok and Aguilar (2000) administered a 'beliefs about language' survey at the beginning and end of their multicultural education course. In the beginning, a majority of prospective teachers reported 'no opinion' or were undecided about statements such as "it is more important for immigrants to learn English than to maintain their native language" (p. 20). However, after investigating topics such as English as a Second Language (ESL) programs and second language acquisition, there was a significant gain in prospective teachers' knowledge or understanding of the items on the survey.

However, while findings such as those presented by Torok and Aguilar are encouraging, Gutiérrez (2002) cautioned the need for critical exposure to issues related to second language learners and mathematics learning less teachers develop stereotypes. One manner in which to accomplish this critical exposure at the teacher preparation level is to involve prospective teachers in situations that allow them to make sense of the theory they are acquiring. As Vomvoridi-Ivanovic and Khisty (2007) found, bilingual prospective teachers needed first-hand experience in a bilingual after-school mathematics club to make sense of the idea that conversational fluency does not indicate academic fluency. In other words, an individual will not necessarily be able to converse fluently with discipline-specific language because they are able to do so in social settings. While all the prospective teachers in the study self-identified as fluent in both Spanish and English, a majority of them were challenged to use Spanish to perform mathematics, facilitate discussions, and assist children in mathematical activities.

It is also important to recognize that some prospective teachers' ideas regarding mathematics and language may be more sophisticated than they appear at first glance. For example, Bunch, Aguirre, and Téllez (2008) found that prospective teachers mainly focused on describing academic language as vocabulary when they investigated the teachers' written responses to prompts included on a state-mandated assessment. However, upon further analysis, the authors realized that many of the prospective teachers focused on how they needed to model vocabulary and use children's own experiences to foster mathematical understanding – ideas which are in concert with effective teaching strategies for ELLs.

Method

Setting

The study was conducted in one section of a mathematics for teaching course at a large research university in the southwestern United States. The mathematics for teaching course is one of two content courses required for all students in the elementary education program and is usually taken one year prior to a mathematics methods course. Since many of the ideas covered in the class, if not all, are ones they have encountered before, one of the primary goals of the course is to help prospective teachers develop deeper and more flexible conceptual understandings of those ideas. Typical content covered ranges from number (numeration systems, number theory, fractions, ratios and proportions, decimals, and percents) to operations on whole numbers and fractions along with general problem-solving strategies.

Children's Thinking Activities

Three sets of in-class children's thinking activities were used as the context to elicit participants' conceptions. These activities were based on lessons involving the multiplication and division of whole numbers and the comparison of fractions. Using video clips produced by the Developing Mathematical Ideas project (Schifter, Bastable, & Russell, 1999) as a basis, prospective teachers investigated different children's invented strategies for solving multi-digit multiplication and division problems. While the activities did not focus on issues of language per se, the instructor of the class (which was not the researcher) had the students consider issues related to language and mathematics and to teaching ELLs throughout the implementation of the activities.

The fraction activities were designed as part of the Center for the Mathematics Education of Latinos/as (CEMELA)[3]. This two-week module showcased four 5th-grade students (all of whom were not ELLs) sharing their mathematical thinking. Prospective teachers considered several mathematical topics while they watched video clips of the children explaining their work, including interpretations of rational numbers, the fractional whole, and equivalent fractions. As a part of the activities, prospective teachers also considered their ideas relating to the interconnectedness of language and mathematics and how it relates to ELLs.

Participants

The participants in this study were four students enrolled in one section of a mathematics for teaching course. All of the participants were invited to participate in the study after the researcher completed several in-class observations. Invitations to participate were made based on observed participation levels in class as well as the prospective teachers' mathematical ability. Since it would be necessary for participants to discuss their ideas, it was desirable to have participants who did not seem hesitant to share their opinions. A range of mathematical ability was also desired as it was assumed that prospective teachers with

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[3] CEMELA is a Center for Learning and Teaching supported by the National Science Foundation, grant number ESI-0424983. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the author and do not necessarily reflect the views of the National Science Foundation.

varying levels of mathematical ability would view and reflect on the activities in different ways. In the end, Jessica, Meghan, Adam, and Hannah[4] volunteered to participate in the study. Table 1 provides a brief overview of each of the participants, followed by a detailed description of each.

Table 1
Description of study participants

	Class Standing	Teaching Interest	Experience in classrooms	Experience with ELLs	Interest in Mathematics
Jessica	Sophomore	Early Childhood	Limited	None	Neutral; felt she was good at it
Meghan	Junior	Third grade	Some	Some	Loved it; felt she was good at it
Adam	Junior	Undecided	Limited	None	Neutral
Hannah	Junior	Kindergarten	Some	None	Did not like it; felt she was bad at it

Jessica was a sophomore who was confident that she wanted to work in early childhood education (birth to age 5). Jessica had limited experiences in the classroom, and she admitted that she had never heard of the phrase *English language learners* before, nor had worked with that population of students in regard to mathematics. Mathematically, Jessica did not love the subject, but she did feel that the material came fairly easily to her.

Meghan was a junior pre-education major, who was fairly confident that she wanted to focus her attention at or around the third grade. Meghan loved mathematics and felt she was pretty good at mathematics. Meghan had interned in a couple of elementary school classrooms, where she worked with many students who were learning English.

Adam was a junior who had just declared Education as his major and who was not quite set on what age range with which he would like to work. Adam had not had many experiences in the classroom, especially working with ELLs. As a learner, Adam described himself as a good student, but lacking passion in any one particular content area including mathematics.

Hannah was a junior pre-education major who always wanted to be a teacher. All of Hannah's informal teaching experiences left Hannah positive that she wanted to focus on becoming a kindergarten teacher, although they did not provide her any interactions with non-native English speaking students. Hannah felt that she was not strong in mathematics, and she admitted that she had to enroll in basic mathematics courses at a local junior college before taking ones at the university.

Data Collection and Analysis

Using a multiple case study methodology, a variety of data was collected to understand how prospective teachers thought about the role of language in teaching and learning mathematics. Specifically, three kinds of qualitative data were obtained: (a) individual and

[4] All names used throughout the write-up of this study are pseudonyms.

small group interviews, (b) direct observations of in-class interactions, and (c) written documents.

Each participant participated in five outside of class semi-structured interviews, three which followed an individual format and two which took place in a group setting. The interviews occurred at the beginning and end of all of the activities and after the completion of each activity. The interviews, each of which lasted about 30-45 minutes in length and was either audiotaped (individual interviews) or videotaped (group interviews), asked participants to consider specific explanations provided in the activities or conversations they may have had in class. Additionally, participants were asked to consider their ideas in general regarding effective teaching practices to teach mathematics to ELLs.

The class instructor asked students sitting together to discuss their thinking and then share part of their discussion with the whole class. All of these interactions were observed and videotaped. These observations, along with the observations before the start of the children's thinking activities to understand classroom dynamics and norms, accounted for 14 visits to the classroom. Additionally, all of the participants' written work was collected and copied at the end of all of the children's thinking activities. This consisted of the complete set of written activities (called *Class Notes*) the participants completed as they watched the video-recordings of children explaining their thinking.

The data were coded and analyzed using elements of Grounded Theory (Corbin & Strauss, 1990). Using an iterative process, conceptually rich and dense accounts of the participants' conceptions grounded in the context of investigating children's thinking activities were created. The data were examined from a unique case orientation (Patton, 2001) where the aim was to capture and be respectful of the uniqueness of each participant. As such, first the main themes within each case were identified. Then all of the themes from all four cases were compared and contrasted in order to establish broader cross-cutting themes.

All of the data were transcribed and subjected to two levels of coding: open coding and reliability coding. For the former, all of the data within each case were read several times and any instances where participants reflected on issues of language and/or working with ELLs were coded by hand. Throughout this process, generative and comparative questions (Corbin & Strauss, 1990) were asked of the data. A sample of the data was then sent to an independent researcher in order to ensure the communicability of the developed codes. The codes from the open coding process and the independent researcher were then compared and any differences in code applications were resolved. Below are sample code definitions:

kidterminology: PSTs' conceptions that the children's thinking is hard to understand because of the children's vocabulary or terminology used.

kidunderstand: PSTs' ideas about the insight into a child's (possible) understanding because of language used by either the child or a teacher.

kidcomfort: PSTs' conceptions that a child uses language that is more comfortable or familiar to them.

Findings

Participants' conceptions about language and mathematics related to the instruction of ELLs fell into three major themes: (1) language as a means to understand mathematical knowledge; (2) the challenge (or lack thereof) ELLs may face while learning mathematical language; and (3) the role of teachers in supporting ELLs' development of mathematical language. The following sections provide detailed descriptions of each of these conceptions..

Theme 1: Language as a Means to Understand Mathematical Knowledge

All of the participants focused on the specific words the children in the activities used, or in some cases, did not use in their explanations. However, the specific ways in which the participants attended to these explanations sometimes varied. At one end of the spectrum, Hannah seemed to feel that children's explanations were a means to provide insight into the processes used by children, something that could not necessarily be ascertained solely by examining children's written work. However, Hannah thought that children did not need to use a set of standard words within their explanations to demonstrate their understanding of a mathematical concept:

> H: I don't think they have to use that [mathematical] language exactly, like word for word . . . if they grasp the concept of how to do it without using those words, I think that's fine. I don't think they have to use "7 is the dividend, divided by this is that' (Group Division Interview, October 18, 2007).

As seen in this example, Hannah felt that children could understand mathematical concepts without the use of specific mathematical terminology, a point she reiterated later in the interview and several times throughout the children's thinking activities. Adam echoed this sentiment, stating that he felt that mathematical language did not need to be used in every situation. Although he said that "the language [of mathematics] is kind of important" (Final Interview, December 12, 2007), Adam felt that oftentimes the language of mathematics is "too scientific . . . really formal" (Group Division Interview, October 18, 2007). Adam believed that mathematical language was not something one might use in everyday speech because "when you're just talking, you don't say stuff like that" (Group Division Interview, October 18, 2007). Instead he saw people speaking in a manner with which they were more comfortable.

In contrast, Jessica seemed to conceive of a single correct way to express understanding. Specifically, Jessica assessed the understanding of the children in the activities through the presence or absence of certain key words and phrases in their explanations. Consider the explanation given by a student (Alexa; see figure 2 for Alexa's work). In her explanation, Alexa shared her reasoning for why she decided that one half was greater than three-eighths, specifically stating

> A: I drew uh, a picture [be]cause it will help me. And I, I drew a whole bar (pointing to the rectangle on top) and cut it in half which is 1/2. And then I colored in 1/2 and then I drew 3/8 (pointing to the rectangle on the bottom) and colored in 3/8. And I

> drew a line from 3/8 to 1/2 (tracing the line with her finger). And 1/2 seems bigger than 3/8. (Alexa, Fifth Grade)

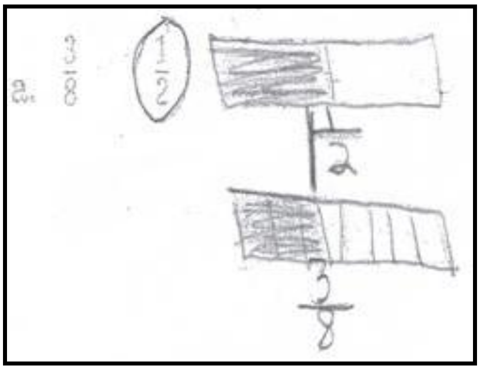

Figure 2. Alexa's work showing why one half is greater than three-eighths

Since Jessica had considered Alexa's explanation and work during the activities, Jessica was asked what she thought about Alexa's mathematical thinking regarding the comparison of one half and three-eighths. In her response, Jessica focused on Alexa's (lack of) reference to the fractional whole as an indicator of Alexa's mathematical understanding.

> J: She's using the word whole bar and cut it in half, which says to me she understands that one half is, or that one over two is half of one, the whole bar. But then she (inaudible) three-eighths; she doesn't say the whole bar there. So that's why I'm uneasy if she gets [that three-eighths is in relation to one whole] … (italics added; Fraction Interview, December 12, 2007)

Jessica's comments imply that she thought there was a correct way to express mathematical thinking. For Jessica, even though Alexa correctly concluded that one half is greater than three-eighths, she was not positive that Alexa understood that a fraction is a part of one whole since Alexa did not express her understanding using a specific set of mathematical terminology.

This idea of using language as a means to understand mathematical knowledge was not unique to Jessica, as evidence of it was also seen in Meghan's dialogue. Meghan asserted that the degree to which someone understands something rests on the specific language one uses. For example, when referring to a simulated student response[5] in the fraction activities, the use of *take away* instead of *subtract* and *plus* instead of *add* signaled to her that a child may not understand the concepts of addition and subtraction fully: "Their use of language is just – very hard to understand: 'take away' instead of 'subtraction;' 'plus' instead of 'addition.' It just – it just makes for difficult understanding, and … it seems like they don't understand what they're doing also (Fraction Interview, December 17, 2007)." Here Meghan focused on the child's choice of words (e.g. plus) to describe specific mathematical operations. For Meghan, these were ineffective at demonstrating the child's understanding.

[5] The response Meghan commented on was "I did 38 take away 96 . . . I plussed 14 and 62…"

Theme 2: The Challenges ELLs may Face

All four case study students felt that learning mathematics involved, and in some cases was facilitated by, learning mathematical language. While they all singled out vocabulary as an important component in learning mathematics, when asked what they considered mathematical language to be, only Meghan defined it as "[a set of] correct terminology [that expresses mathematical] concepts" (Final Interview, December 17, 2007). More common was the idea that mathematical language is the means with which to communicate mathematics. Adam perceived it as "mathematical diction" (Final Interview, December 12, 2007), and Hannah considered the inclusion of mathematical syntax: "… people can be like 'you're adding, you're multiplying . . . stuff like that. But then like when you get into math and numbers and variables, like it makes it difficult" (Initial Interview, September 27, 2007).

While Jessica was hesitant to define mathematical language, she thought that using it required more than just memorization of rules and terminology:

> J: Well, just like, kind of like in Spanish, like if you don't understand like just, the basics of it, you're not going to get anywhere with it. You know? You can memorize all of the words; you can memorize you know, all the traits; and you can know, you know, what they're equal to. But if you don't understand how to put them together, like the sentences or all the different rules or when you put this and that together… (Final Interview, December 13, 2007)

What Jessica was reflecting on was that in order to truly communicate mathematical thought an individual needs to know how to make and use connections among the terminology and structures. Jessica further expanded on her view, relating learning mathematical language with her own experience of learning Spanish:

> J: Like a lot for me in Spanish, that was what I struggled with. It's like I'm great at memorizing, you know, all of the words, and the numbers, and the holidays and everything . . . [but] once you have the memorization, then you have to know what to do with it. And I think it's the same in math. (Final Interview, December 13, 2007)

Jessica's thoughts speak to the idea of fluency. It appears that for Jessica communicating in mathematical language was much more complex than simply using proper terminology.

Regardless of their views, all of the participants acknowledged that all children, including ELLs, should be proficient in the language of mathematics. Two participants, Jessica and Hannah, also shared their ideas that ELLs might face obstacles when acquiring mathematical language in an English-only classroom. As Jessica explained in her *Class Notes*, "Math language is hard enough even for me to grasp as an English speaker as my first language. I can only imagine what it would be like on top of learning the English language as your second language" (p. 33). In her class work, Hannah discussed this possible difficulty in learning mathematical language, sharing her view that "math language is hard enough and with having to learn it in English, [it] can confuse that person [an ELL] and they may not grasp the concepts of mathematics. There are words in math that you won't hear anywhere else" (Class Notes, p. 33). As seen in both statements, Jessica and Hannah referenced their own difficulties as native English speakers to contextualize the challenges ELLs might face when learning English and mathematical language simultaneously.

Meghan, on the other hand, thought that ELLs would have an easy time acquiring mathematical language. This was primarily due to her view that ELLs would be ignorant of what Meghan considered to be slang mathematical terms (e.g. plus and minus): “They’re not going to understand English. So they’re not going to know the slang math terms, so they can learn the correct terminology right off the bat” (Final Interview, December 17, 2007). Meghan’s conception seems to demonstrate her lack of quality experience working with ELLs and people different from her. Further, her use of the phrase ‘correct terminology’ illustrates the claim that she valued one set of mathematical words over another.

Theme 3: The Role of the Teacher

All of the participants discussed the need for teachers to stimulate the mathematical language development of ELLs. First, all of the participants acknowledged that the choice of words by a teacher impacts what a child will understand. Because children are influenced by the language used in the classroom, the participants argued, there is need for teachers to model the academic language they expect of children. In response to the class instructor’s question regarding the use of mathematical language by a teacher, Jessica explained, “Like I don’t think I would throw it out there [mathematical language] without telling them [what it is or what it means]…” (Division Activities, Day 1). After revisiting the teacher’s question in the group division interview, Hannah shared that if a teacher uses non-standard language “like ‘that thingy’ and . . . ‘this thingy,’ [the students] are gonna look at you like you’re crazy. They’re not going to understand” (October 18, 2007). This use of mathematical language as a means to develop students’ conceptual understanding was at the heart of Meghan’s reflection on her own experience in elementary school:

> M: I think that if my teacher had used the correct terminology, not just that, ‘five can’t go into one.’ . . . [and instead had said] something like ‘one block of one hundred can’t be divided like that,’ then it might have helped with understanding. I think it’s very important to use correct terminology, or else they’re just mindlessly doing a problem instead of understanding what they’re doing. (Division Interview, October 23, 2007)

For ELLs, Adam felt that teachers should model a more focused form of mathematical language. Namely, he argued that teachers should avoid using synonyms, such as *add* and *plus*, interchangeably as a way to minimize confusion for ELLs:

> A: Yeah, . . . I mean if you're [the teacher] in the classroom and trying to explain something and are using a bunch of different synonyms like ‘this plus this,’ ‘this many more,’ it makes it difficult. But if you're just saying ‘this plus this’ all the time then it will be easier [for ELLs] to pick up.” (Final Interview, December 12, 2007)

The participants also felt that teachers could support ELLs’ development of mathematical language by providing them opportunities to share their mathematical thinking. For Hannah this type of environment was important because in her view

H: you can understand how they got . . . their answer, how they solved the problem so you kind of understand where they're coming from versus just like saying it. Because if you [just] see it, you may not completely understand what they did, but if they explain it then it might make more sense. (Group Multiplication Interview, October 17, 2007)

More than just providing teachers' insight into what children are thinking, Jessica also thought that a classroom that emphasized mathematical discourse would provide ELLs support in both their practice of mathematics and language. Meghan further hypothesized that through discussion, ELLs might connect with fellow classmates who also speak their language and that together they could construct understanding.

Discussion

The children's thinking activities appear to have created a space for participants to consider issues regarding the language of mathematics and the mathematics education of ELLs. The following sections contextualize the participants' conceptions in relation to the conceptual framework of the study.

Theme 1

Two of the prospective teachers, Jessica and Meghan, seemed to privilege one form of mathematical discourse through their discussions regarding the existence of a set of correct terminology in mathematics. This form of privileging, which is in contrast to what researchers argue for when working with ELLs (e.g. Moschkovich, 2000; 2002), could disregard ELLs' mathematical thinking if their language did not match a pre-determined set of correct words. Many ELLs balance learning the nuances of multiple registers simultaneously with learning mathematics. Therefore it is possible that they may be judged to lack knowledge if they struggle to maintain that balance. What is important for teachers to consider is that the use of mathematical language does not necessarily correlate with knowledge of mathematics. As Secada and Carey (1990) argued, people can appear to be informed through their use of language without possessing the corresponding mathematical understanding.

Unlike Hannah's and Adam's notion regarding the acceptance of multiple forms of mathematical discourse in the classroom, Jessica and Meghan also implied that they desire their students to communicate in only one way. For ELLs, this desire might impact how they achieve mathematically. As Khisty (1995) explained, if ELLs only know one way to express their understanding, they might become lost in conversations where synonymous terms are used. Furthermore, by limiting the number of ways ELLs express their thinking, one limits the number of ways that they can construct meaning (Schleppegrell, 2007). Instead, teachers can use ELLs' multiple forms of language, including their everyday language, as a tool to help them develop their mathematical thinking (Barwell, 2005).

Theme 2

The participants, in general, defined mathematical language in unexpected ways. In their study regarding teacher candidates' views on the relationship between language and mathematics, Bunch, Aguirre, and Téllez (2008) found that a majority of individuals associated the academic language of mathematics with vocabulary. However, in this study only one of the four participants perceived mathematical language as synonymous with vocabulary, while the other three participants discussed mathematical language in more complex ways. Previous research in the field supports the more nuanced view of mathematical communication to which Hannah and Adam alluded. Mathematical language takes on many different forms including symbolic, linguistic, and pictorial (e.g. Schleppegrell, 2007); combines everyday and technical words (e.g. Moschkovich 2002); and involves logical connectors such as *if … then*, structures something with which all children, but especially ELLs, struggle to understand (e.g. Anhalt, Fernandes, & Civil 2007).

The complexity of mathematical language was evident in Hannah's and Jessica's conceptions about the challenges ELLs may face when acquiring mathematical language. In her remarks to the National Mathematics Panel, Leiva (2006) echoed the challenges discussed by Hannah and Jessica, noting that even children whose primary language (L1) *is* English find it difficult to learn the language of mathematics. According to Gutiérrez (2002), the sympathy displayed by Hannah and Jessica when discussing the difficulties they have with the language of mathematics is not uncommon for some elementary teachers. Typically these teachers tend to be more child-centered and less tied to a specific body of content.

On the contrary, Meghan, as a person who loved mathematics, may have been more tied to the subject of mathematics and thus less able to conceive of the challenges that ELLs might face when acquiring mathematical language. These conceptions, if unchallenged, might then impact how Meghan provides instruction to ELLs. In stating that in essence ELLs are *tabula rasa* in regard to learning mathematical language and without acknowledging the complexities that are involved in learning a language, as a teacher Meghan might not be able to capitalize on the knowledge of language that children do possess. Furthermore, she might not be able to use the children's knowledge of language to move them toward a deeper understanding of mathematics (Schleppegrell, 2007).

Theme 3

While the participants differed in their view of what counts as mathematical language, they all viewed the modeling of it as an important component of instructional practice, especially in regard to supporting ELLs. This view, maintained Khisty and Chval (2002), is vital for teachers of ELLs. ELLs need to know not just mathematical terms but what the terms mean and how they should be applied in different contexts. This view though is in contrast to Adam's sentiment. While he too felt that teachers of ELLs should model mathematical language, he felt that teachers should avoid using synonyms interchangeably in order to simplify language learning for ELLs.

Adam is correct in assuming that some ELLs (and some native English speakers for that matter) might be confused if teachers use words interchangeably without calling specific attention to the related meanings. As Hannah noted in her written work and as research (e.g.

see Barnett-Clarke & Ramirez, 2004; Moschkovich, 2002) has discussed, there are words in everyday language that have a different meaning in mathematics and some that only make sense in a mathematical context. However if teachers pare down their language too much, they limit the number of connections that ELLs can make between what they already know and understand and the new ideas/words they are learning.

Without downplaying the challenges that ELLs may face, there is substantial evidence that ELLs can and do communicate mathematically – they learn to explain their thinking and to make their ideas clear to others (e.g. Khisty & Chval, 2002; Moschkovich, 2002). However, they often draw on a broad range of resources to do so. Therefore, ELLs need to be provided multiple opportunities to draw on these resources, which includes the use of gestures, objects, primary language, and everyday experiences (Moschkovich, 2002), in order to communicate their mathematical thinking. This is especially important to consider for the instruction of ELLs as "native [English] speakers begin with a more advantageous language base" (Bialystok, 2008, p. 108) due to their everyday and informal experiences with the English language. Therefore, instead of simplifying the language by only using one set of terminology, researchers (e.g. Barnett-Clarke & Ramirez, 2004; Gutiérrez, 2002; Moschkovich, 2002) advocate that teachers point out distinctions among words that overlap registers and capitalize on the resources ELLs bring to the classroom.

Implications

The analysis of children's written work and explanations provided participants a context in which they could articulate their ideas regarding language and mathematics. However, there is a need to develop and implement children's thinking activities that focus specifically on ELLs both successfully and unsuccessfully grappling with rich mathematical ideas. Consider again the participants' views regarding the obstacles ELLs may face when acquiring mathematical language in an English-only classroom, When implementing children's thinking activities based on ELLs, what obstacles, if any, might prospective teachers observe? Further, would the observations be different based on teaching interest (e.g. high school vs. elementary)? Ideally, these activities would involve a range of children (e.g. gender, age, ethnicity) and include the children speaking about mathematics in their own words.

The findings from this study support the argument that integrating issues of educating ELLs into mathematics teacher preparation, be it through activities and/or field experiences that focus on working with ELLs, is a necessity (Lucas, 2011). The conceptions articulated in this paper, some of which are in-line with recommendations from research and some of which are not, were formed prior to methods or multicultural education courses (where issues of teaching ELLs are historically addressed). Due to time constraints and the vast amount of material that needs to be covered in these courses, thoroughly investigating specific content domains such as mathematics in relation to ELLs is not feasible. Children's thinking activities in mathematics for teaching courses are but one set of experiences that have the potential to help prospective teachers confront and challenge their ideas regarding the mathematical instruction of ELLs.

However, achieving an integration of these types of activities into mathematics teacher preparation necessitates instructors to critically address issues of language in relation to mathematics instruction. In this study, while the instructor had students voice their conceptions related to language and mathematics and to the instruction of ELLs, her primary focus was not an integration of these ideas into the curriculum. To do so would have required a reconstruction of her pedagogy. To restructure one's practice in the way called for here requires time, effort and patience as well more professional development for teacher educators. As Merryfield (2000) explained,

> We know very little about the ability of college and university faculty and other teacher educators to prepare teachers in multicultural and global education. Do today's teacher educators have the knowledge, skills and commitment to teach for equity and diversity either locally or globally? (p. 430)

Costa, McPhail, Smith, and Brisk (2005) provide us a model of how to achieve this type of professional development. In their work, they discuss how the faculty of a teacher education program sought to become better educated in how language affects classroom learning. The faculty hypothesized that by doing so "[they could] also help aspiring teachers increase their awareness of specific language challenges to classroom learning that ELLs face" (Costa et al. 2005, p. 106).

Using this as a model, then, faculty within a mathematics teacher preparation program can form professional development groups where they can grapple with their own knowledge and beliefs about integrating issues related to the instruction of ELLs into their coursework. For example, using the findings from this study as a basis, faculty can form a Teaching Circle where they discuss how they might have challenged the conceptions about privileging one form of mathematical discourse over another or asked prospective teachers what the impact would be for ELLs if they avoided using synonymous language within their teaching. Further, they could discuss how they might critically expose prospective teachers to literature regarding ELLs within the context of developing the prospective teachers' mathematical conceptual understanding.

Of interest for future research would be to see how prospective teachers' conceptions regarding language and mathematics develop over time. This type of longitudinal study could involve following a group of prospective teachers from a mathematics for teaching course, to a course focused on teaching for diversity, through their mathematics methods course, into their student teaching practicum, and finally into their first year of teaching. The goal of such a study would be to not only see how the prospective teachers' ideas change over time but to also capture what might account for such changes. The potential findings could inform teacher educators about what experiences could be provided to challenge prospective teachers' conceptions.

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