

THE MULTIDIMENSIONALITY OF LANGUAGE IN MATHEMATICS: THE CASE OF FIVE PROSPECTIVE LATINO/A TEACHERS

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This paper reports a study of prospective bilingual teachers and the intersectionality of language and mathematics in a non-traditional field experience. Qualitative data were analyzed in order to map Spanish and English language practices to teachers' assistance strategies. We define assistance strategies as those actions that are intended to help students understand content. Findings demonstrate the complexity of prospective teachers' use of language in mathematics teaching and suggest implications for teacher preparation programs.

Preparing teachers to become linguistically responsive educators has been a current issue in Teacher Education (Darling-Hammond, & Bransford, 2005). Most work relating to this issue has been done on monolingual prospective teachers, while there is very little work on bilingual prospective teachers, especially in the domain of mathematics. The purpose of this paper is to report a study designed with the intent to investigate how prospective teachers grapple with the intersectionality of mathematics learning and language through their participation in a non-traditional field experience. The participants were Latina/o prospective teachers who served as facilitators in *Los Rayos de CEMELA*, and after-school project. Specifically, this paper examines how shifts in language use (English – Spanish) relate to prospective teachers' interpretations of students' mathematical engagements and the subsequent assistance strategies they use with students. We define assistance strategies as those actions that are intended to help students understand content. The study describes how language choice mediates assistance in doing mathematics.

The study presented here draws on current work carried out by the Center for the Mathematics Education of Latinos/as (CEMELA)ⁱ which focuses on the research and practice of the teaching and learning of mathematics for Latino/as in the United States through the integration of socio-cultural theory, language, and culture. CEMELA has created after school projects at two of its sites, one of which (*Los Rayos de CEMELA*) is the source of the present study. The after-school projects are designed to investigate the linguistic and cultural resources that support bilingual Latino/a students' mathematics learning. and are a general adaptation of the work of the Fifth Dimension (Cole, 1996). *Los Rayos* is guided by other similar projects (e.g., Gutierrez, Baquedano-Lopez, & Alvarez, 2001) including *La Clase Mágica* (Vasquez, 2003). These works have utilized the after-school as a way of understanding literacy; CEMELA has extended the work to consider mathematics.

Theoretical framework

To understand the complex nature of the mathematical activities and the interactions that take place in *Los Rayos de CEMELA*, we use both a socio-cultural and an activity theoretical view of learning and development. Through these lens we focus our analysis on the prospective teachers' interactions with children and on their reflections on mathematics teaching and learning.

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Cultural historical theory (Vygotsky, 1978) shifts the view of learning from an individual internal phenomenon to one based in social interaction. Higher mental processes derive from external and practical actions or activities between people. These actions are mediated by signs and tools, including language which is the most prevalent. Language also may be the most important semiotic tool because it is the most obvious and natural means that people use to make sense of phenomena, to transmit values and beliefs, and to socialize children into the practices of a culture (e.g., Halliday, 1993; Lave & Wenger, 1991; Vygotsky & Cole, 1978; Wells, 1999).

The after-school setting is a tool in itself in that it presents a different yet familiar setting from a traditionally structured teaching practicum or tutoring-oriented activity. *Los Rayos de CEMELA* embeds students' self-motivated actions and interactions with others that together form a "cultural practice". The way mathematics is done in the after-school is different from how it is done in classrooms, perhaps in small ways, but nevertheless different. This difference challenges students' assumptions about what it means to do mathematics and in this way forms a "practice" of doing mathematics. At the same time this difference challenges the facilitators' (in this case the prospective teachers') assumptions about what it means to assist students in doing mathematics while utilizing a variety of linguistic and cultural resources. Through their participation in *Los Rayos de CEMELA* prospective teachers are involved in hybrid practices which are "polycontextual, multivoiced, and multiscripted" and help create a *Third Space* which allows for assumptions and connected actions to emerge in a natural way (Gutierrez, Baquedano-Lopez, & Tejada, 1999).

Methods

Five (four female and one male) Latino/a pre-service elementary teachers in their junior year were recruited during the second week of their mathematics methods course in Fall of 2006. All participants self identified as being fluent in both Spanish and English and four of them (all females) are seeking endorsements in bilingual education.

The participants met with fourth-grade students in *Los Rayos* once or twice a week for one and a half hours each time through an eight-week period during the Fall 2006 semester. Each participant worked with a group of two to four students during each session and was encouraged to serve as a sibling-like "more experienced other" rather than a mathematics tutor or teacher. All sessions in the after-school were videotaped. Additionally all participants were required to take detailed field-notes of their interactions with the students focusing specifically on how language (Spanish and/or English) was used, on students' mathematical strategies, and on their own assistance strategies. Furthermore, each participant played the role of *el Maga* (a bilingual math wizard) who communicated electronically with the students twice a week (via a message board) about mathematics. The students were not aware of who actually wrote as *el Maga*, and this situation encourages a free and natural exchange between correspondents. Finally, during this eight-week period, all participants met in a weekly a two hour debriefing seminar designed to engage participants in active discussions about students' linguistic and mathematical behaviors and interactions, and the participants' own reflections about the same items. All seminars also were audio-taped.

In order to map language use with assistance strategies data were analyzed using a constant comparative method (Glaser and Straus, 1967) in which relations amongst language choice and assistance strategies used, became apparent as the data were continuously examined.

Evidence

Data analysis reveals two patterns regarding language use and assistance strategies. Firstly, assisting students in mathematical activities in Spanish proved to be a challenge for most of the prospective teachers. They realized that fluency in conversational Spanish does not translate to fluency in academic (in this case mathematical) Spanish. Secondly, language was used in fluid and non-determined ways. There was no evident predictor for the language each prospective teacher chose to use and language choice was not always conscious or purposeful. We use Patton's (2002) intensity sampling strategy - whereby cases which represent categories of extreme interest are focused on in more detail - in the selection of cases to present patterns in language use and assistance strategies. For challenges involved in the use of Spanish when assisting students in mathematical activities we draw upon the experiences of Julieⁱⁱ, and to describe how language was used in fluid and non-determined ways when conversing with children about mathematics the experiences of Rex are discussed. Both cases highlight the role of language in assisting students.

Challenges in doing mathematics in Spanish

All study participants self identified as being fluent in Spanish and English. In fact, all participants' first language is Spanish. However, doing mathematics in Spanish, facilitating mathematical discussions in Spanish, and assisting students in mathematical activities in Spanish all proved to be a great challenge for three out of the five study participants, namely Julie, Deborah, and Rex.

During the first debriefing meeting, prospective teachers were asked to do the mathematical activities they were going to use with the children in *los Rayos* that week. All activities were provided in both Spanish and English, in the same forma that students would get them. Julie chose to use the Spanish version of the activities and informally teamed up with two other prospective teachers, Diana and Sonia, who also chose the Spanish version. The following describes Julie's experience with the Spanish materials.

While Julie was reading the activity she frowned and said "WHAT?" She then resorted to the English version of the activity. After reading it in English she said "Oh, now I get it!" and solved the problem right away. Julie kept resorting to the English version of the activities and although she discussed the context of the activities in Spanish she would resort to English when talking about mathematics. Later on, she reflected on her difficulty in understanding mathematical Spanish:

Julie: ...well like cause you if know let's say your L1 is Spanish but you like you know English, if they give you a word problem and it's in English you would be able to do it but then if they give it to you in Spanish you won't be able to do it. Does that make any sense?

Eugenia: O.k. can you say that again? So what's your first language?

All: Spanish.

Eugenia: So English is your second

Julie: But I learned English, I learned English math. So if they give me a word problem like they did like today and I read the Spanish one I had to reverse and I had - I - I know how to read Spanish and I understand it but I comprehend math a lot better if I read it in English...like I'll read it and I'll be "o.k..." but when I - when I flip it over I'll be like "Oh o.k.! O.k. umhum!" You know?

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Julie was seeking bilingual endorsement at the time of the study and had read in their bilingual education course that conversational fluency in one cultural language does not translate to academic fluency in the same cultural language. However, it was not until she experienced trying to comprehend, discuss and solve a mathematical problem in Spanish that she realized this. Julie had a hard time comprehending the mathematics in the problem she was given and had to resort to the English version of the problem because she had learned mathematics in English. She started to realize that the reason she was not able to think about mathematics in Spanish was because she had never been taught mathematics in that language. In other words, Julie was not familiar with Spanish mathematical discourse and this resulted in her difficulty comprehending the Spanish mathematical text, even though the problem involved elementary mathematics in which she was competent.

During the after-school sessions, Julie would use both English and Spanish – mostly code-switched - with the students she worked with. She would always make a considerable effort in making sure that the mathematical conversations in her group were done in both languages as she realized the importance of children being exposed to mathematical talk in both Spanish and English. In a personal conversation with one of the researchers, she expressed that she felt saddened by the fact that she had a hard time thinking and talking about math in Spanish and she wanted to make sure that her students would not share the same experience as she did. In addition to this, Julie expressed many times during the debriefing meetings that it was necessary for her to read the English version of the activities and then solve the activities in English before attempting to assist students in Spanish.

Julie: I feel like if I could read an English worksheet then I could translate it in Spanish but if I get a Spanish worksheet and I read it then I'll take a lot longer to understand it... cause I could translate it and I could teach it to them in - well not teach - in Spanish.

Deborah: Me too. Exactly.

Rex: Yea the same way.

Even so, Julie found it difficult to assist students in mathematics using Spanish only. Instead she would blend Spanish and English in both mathematical and non-mathematical discussions. Code-switching came very natural to her and the students she worked with during non-mathematical discussions. However, during mathematics Julie consciously blended both vernacular and mathematical talk in Spanish and English as an effort to experiment with and expose her students to Spanish mathematical discourse. Julie later indicated in her field-notes that she had become so used to code-switching in Spanish and English during the mathematical activities that she preferred the activities that were written in a format that blended the two languages in the same sentences and paragraphs. In her field-notes, she said: "...one thing I did like about this problem was that it was both in Spanish and English because it was written in a way that many students speak, including myself..."

This example shows the difficulty that teachers like Julie, as well as Deborah and Rex, who are Spanish bilingual but not biliterate (e.g., able to speak, read, and write mathematics) face in thinking and talking about mathematics in Spanish. However, the three prospective teachers dealt with it differently; one blended the two languages in all contexts, one only in non-mathematical contexts, and one stayed with English only.

Language choice

Unlike Julie who consistently code-switched when communicating with the students in *los Rayos*, Rex and Deborah used mostly English while Diana and Sonia used mostly Spanish. An interesting finding is that in numerous instances participants used English (instead of Spanish) when facilitating a mathematical discussion with a group that had a Spanish dominant student present but never used Spanish when an English dominant student was present. For example, Sonia and Diana would switch to English (and facilitate group mathematical discussions in English) when an English dominant student joined their groups, even though Spanish dominant students were present in the same group. On the other hand, Rex and Deborah would not switch to Spanish when a Spanish dominant student was present in their group. Instead they would continue carrying on the mathematical discussions in English. The only times Spanish were used in these cases was during non-mathematical conversations and/or to discipline the students.

Rex's language choice presents an interesting example. One of the students in the group he facilitated, Rafael, was Spanish dominant and would consistently choose the Spanish version of the activities, while the other two students (Rodrigo and Mario) would choose the English version most of the times. Rex would facilitate all mathematical discussions in English because (as indicated in his field-notes) he assumed that the students had been taught mathematics in English only and because they would always talk about mathematics in English. However, after working with the same children for four weeks, Rex noticed a switch to Spanish while playing a math game called "the grocery cart game." In his field-notes he wrote:

"...Another interesting event happened today when the students started speaking in Spanish. I believe Rodrigo started it when he spoke about items on the menu in Spanish and Rafael responded in Spanish. They then went to add the items' price in Spanish. It seemed like Rafael added in Spanish by that he said the numbers, counted the numbers, and used terminology in Spanish.

Rex observed that Rafael used Spanish exclusively when doing the mathematics involved in the game. In later field-notes he indicated more instances during which Rafael resorted to Spanish when talking about the mathematics involved in the group activities. Yet he did not use any Spanish when conversing with Rafael about mathematics and continued talking to him in English. In his field-notes he frequently noted that Rafael (the Spanish dominant student) was not engaged with the mathematical activities and was often "off task."

However, when Rex conversed with Rafael via the electronic message board, the language used by both of them was always Spanish. Additionally, the entire dialogue between *el Maga* (Rex) and Rafael was about mathematics. Rafael kept challenging *el Maga* with math problems and *el Maga* responded by posing a new problem for Rafael. Rafael, in turn, who was "off task" during the group activities was extremely engaged in trying to solve the problems *el Maga* posed. In fact, there were a couple of instances where he would not leave *los Rayos*, the after-school, until he solved *el Maga's* problem. As an illustration of the *el Maga/Rafael* dialogue we have chosen the following:

Roberto: Hola maga. Cuanto es 5076 menos 6987 si lo saves dimelo? Bye maga que diviertas hasta quando sea miercoles. [*Hi Maga. What is 5076 minus 6987? If you know tell me. Bye maga I hope you have fun on Wednesday.*]

El Maga (Rex): Hola Roberto. La respuesta es -1911. Es un numero negativa. Sabes la respuesta de 125 suma 875? Cuidae y portate bien. [*Hi Roberto. The answer is -1911. It's a negative number. Do you know the answer to 125 plus 875? Take care and behave.*]

Roberto: Hola maga. Como estas? El numero que me diste que eran 125 mas 875 yo lo tengo. Era 1000. Yo te quiero dar otra esta va ser muy difcil. Es 1,000,000,000 mas 2999,999,875,564? [*Hi Maga. How are you? The number that you told me that 125 plus 875 was I have. It was 1000. I want to give you another one. This is very hard. It is 1,000,000,000 plus 2999,999,875,564?*]

This is a very typical example of how *el Maga* and Rafael communicated via the electronic message board. Rex used the message board as a space for having a mathematical dialogue with Rafael in Spanish, and Rafael used it as a space to explore more challenging problems.

The forgoing examples of choices in language raise the following questions: Why did Rex continue carrying mathematical discussions in English with his group, even though he became aware of Roberto's dominance in both conversational and mathematical Spanish? Was this to accommodate the other two students who he had identified as being English dominant? Why did he not accommodate the Spanish dominant student? Was this because Rex, the prospective teacher, had a better written command of mathematical Spanish but felt insecure about his oral command of it? Was his language choice a conscious one?

Results and Conclusion

Findings from this study reveal the complexity of the interplay between language and mathematics. We examined bilingual prospective teachers and found that the use of two languages as a teaching and learning resource is not as straightforward as one would think. Being fluent in two languages does not necessarily mean that one can do or teach mathematics in both languages. Results suggest that mathematics educators need to rethink what is involved in teaching and learning mathematics in two languages and how complex this can be. However, if we wish for teachers to be equipped with the means to adequately address ELL and bilingual students' needs in mathematics, the Mathematics Teacher Education research community must investigate more (new) ways of preparing prospective teachers to meet these students' needs.

Conceptualizing the nature and role of language and culture in the teaching and learning of mathematics is not an easy task and research in this domain is in its infancy. According to Zeichner (2005) "the research on the preparation of teachers to teach underserved population should pay special attention to the preparation of teachers to teach English-Language Learners, because almost no research has been conducted on this aspect of diversity in teacher education." Even though there is a growing body of research on Latinas/os in mathematics, research that investigates the preparation of teachers to teach mathematics to Latinas/os who are English-Language Learners or bilinguals is almost non-existent.

Relationship of Paper to Goals of PME-NA

This research project was conducted with the intent to better understand the socio-psychological aspects of doing mathematics and assisting children with mathematical activities in two languages (Spanish and English.) In order to understand how to better prepare teachers to address the specific needs of students who are marginalized from the

educational system in the United States, such as ELLs and bilingual Latinas/os, we must understand the complex factors that affect and shape prospective teachers' experiences in doing and facilitating mathematics in two languages. Through the examination of bilingual Latina/o prospective teachers' experiences as facilitators in a mathematics after-school setting, we highlight the need for providing prospective teachers with more opportunities to experiment and investigate the role and nature of language in mathematics.

Endnotes

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ⁱⁱ All names are pseudonyms, which participants chose for themselves.

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