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Language and Mathematics: Questioning Strategies in a Dual Language Bilingual Education Classroom

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This study presents an emerging framework of teaching moves for teaching mathematics in a DLBE classroom. Our preliminary findings indicate how the teacher in our study uses language during mathematics instruction to a) support the development of conceptual understanding, b) create opportunities for cross-linguistic connections, and c) create opportunities to support bilingual students' linguistic and mathematical understanding.

Keywords: Curriculum, Elementary School Education, Classroom Discourse, Equity and Diversity

Introduction

In this research report, we present an emerging framework of teaching moves for teaching mathematics in a DLBE classroom. We use examples from the linguistic interactions enacted by a 4th-grade teacher, Ms. Lucía, with her students during mathematics instruction. We identify salient elements throughout her mathematics instruction that provide insight into how Ms. Lucía approaches questioning strategies: 1) to elicit bilingual learners' responses during class discussion, and 2) to explore how she uses Spanish while formulating questions during mathematics instruction.

Our present work is guided by two theoretical frameworks. First, we use Moschkovich's (2015) framework of academic literacy in mathematics that suggests language learning goes beyond simply learning new vocabulary. Second, we build on Bunch's (2013) definition of pedagogical language knowledge (PLK). This particular viewpoint provides insight into how teachers should negotiate language within the context of a particular academic discipline. Supported by these frameworks, our study is guided by the following research question: how does a dual language teacher use Spanish to implement questioning strategies designed to teach problem solving strategies to (Spanish-English) bilingual learners?

We approach this question by documenting the use of Spanish and English during instruction that centers on teaching mathematics based on students' mathematical thinking. In addition, we attempt to explore the balance between language and content instruction in a DLBE classroom. Documenting the elements of this interaction is a key step in promoting the development of teaching expertise in dual language classrooms. We seek to maintain rigorous mathematics content by ensuring the development of bilingualism among students.

A Word on Terminology

The following terms will be used throughout this research report: *bilingual* students, classrooms, and teachers. By using the term *bilingual*, we refer to those teachers and students who speak English and Spanish and those who are actively engaged in learning English or Spanish as a second language (i.e., both simultaneous and sequential bilinguals). In the present work we adopt the term Dual Language Bilingual Education (DLBE) as noted in Menken's

Otten, S., Candela, A. G., de Araujo, Z., Haines, C., & Munter, C. (2019). *Proceedings of the forty-first annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. St Louis, MO: University of Missouri.

(2017) work. We will refer to DLBE classrooms as those intentionally serving students who are learning academic content in two languages: in this particular case, Spanish and English.

Conceptual Framework

For decades, research in mathematics education has documented best practices for learning mathematics; understanding children's mathematical thinking; focusing on the process of learning mathematics, of problem solving in mathematics, and of discussing mathematical ideas as revealed through children's strategies (Carpenter, Fennema, Peterson & Carey, 1988; Boaler & Staples, 2008; Carpenter; Fennema; Franke; Levi & Empson, 2015). The exchange of ideas about problems, solution strategies, and mathematical connections closely aligns with the mathematics education reform view of what it means to do and learn mathematics (NCTM, 2014). Despite growing evidence that discussions during mathematics instruction can support students' learning, counterbalancing literature suggests that all students may not benefit in the same way from discussion-oriented instruction (Turner, Dominguez, Empson, Maldonado, 2013). Studies by Civil & Planas (2011) have shown that students who are less familiar with the language of instruction, culture, and classroom norms are often marginalized or invisible during classroom discussions. Our work presents a window into a mathematical discussion in a DLBE classroom.

Our purpose is to identify the potential benefits of discussion for linguistically and culturally diverse students. In addition, we attempt to analyze instructional moves tailored to provide ample opportunities to capitalize on students' thinking and linguistic repertoires. Recent work by mathematics educators across the country adds to the perspective of our work by incorporating culture, language, and social differences into mathematics instruction (see Aguirre, Mayfield-Ingram, & Martin, 2013; Turner & Celedón-Pattichis, 2011; Turner, Dominguez, Maldonado, & Empson, 2013; Maldonado & Krause, 2017; Maldonado, Krause, & Adams, 2018). These perspectives impact lesson development, mitigating the overemphasis on learning English (Gándara, et al., 2010), and the narrow focus within the teaching and learning of mathematics in bilingual contexts which tends to underline, for the most part, supporting bilingual students as they solve word problems and tackle standardized tests, without fully recognizing the linguistic complexity of such endeavors (see de Oliveira, 2012; Martiniello & Wolf, 2012). Our work contributes to the literature by offering an understanding of the language practices a bilingual teacher enacts in the context of teaching and learning mathematics.

Methods

This case study (Guba & Lincoln, 1981) facilitates a deep exploration and a robust description of the teacher's and students' academic language negotiation in a DLBE classroom within the context of mathematics. We conducted classroom observations during mathematics instruction in Spanish, debriefed after each observation with Ms. Lucía, and collected students' artifacts. We then analyzed Ms. Lucía's teaching practices to explore how she approached her instructional decisions.

Data and Participants

Our 4th grade DLBE classroom is located in the Tidewater region of Virginia. Libertad Elementary School (pseudonym) is currently a PK-4 elementary Title I and Title III school with approximately 300 students. Ms. Lucía's DLBE classroom has 14 students. Eight students are native English speakers, six native Spanish speakers. Both groups of students intermingle

throughout the day, receiving academic instruction in all content areas 50% of the time in English and 50% in Spanish.

Analysis

Using Charmaz's (2006) Constructivist Grounded Theory we began by transcribing each debriefing session and classroom observation. We read the transcripts to gain insight into the data, and we identified words and phrases that resonated while reading the data. We then wrote memos to examine our thoughts and identified patterns in the data. We conducted an initial coding phase which involved identifying segments of the data with short phrases that represented what was happening in the segment. After discussing and deciding on more simplified codes for the segments, we moved to a focused, selective coding phase to separate, sort, and synthesize our segments. Finally, we synthesized all of this information to develop profiles that reflected teaching moves. We double-coded the data, with discussion and resolution of discrepancies

Tasks

Ms. Lucía started the class with a discussion about interpreting decimal numbers using a 10-by-10 grid (see Figure 1). The task consisted of writing the decimal represented in the figure. After the class discussion, they worked on the second problem (see Figure 2). Ms. Lucía translated the problem into Spanish from a problem found in the pacing guides for 4th grade.

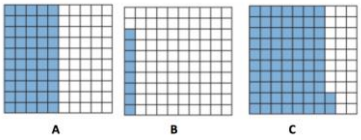

Figure 1: 10-by-10 Grids

En el primer día de clases, el profesor puso 1 centavo en un frasco. En el segundo día de clases el profesor puso 2 centavos en el frasco. En el tercer día el profesor puso 4 centavos en el frasco. Todos los días el professor puso el doble de monedas en el frasco del día anterior ¿Cuántos centavos habría en el frasco en el quinto día de clases?

[On the first day of class a teacher placed 1 penny in a jar. On the second day the teacher placed 2 pennies in the jar. On the third day the teacher placed 4 pennies in the jar. Every day the teacher placed twice the number of pennies in the jar than the day before. How many pennies would be in the jar on the fifth day of classes?]

Figure 2: Word Problem Used in Problem Solving Lesson

Findings and Discussion

Through a systematic analysis of Ms. Lucía's instructional practices, and the language she used during her questioning strategies in Spanish, three themes emerged.

Incorporating Language to Increase Mathematical Conceptual Understanding

While attempting to tease out the definition of *doble* [double] when unpacking the word problem (Figure 2), Ms. Lucía utters the following question: "¿Qué es *el doble*?" [what is *double*?]. One student was quick to provide the corresponding English: 'double'. Ms. Lucía then asked the following question: "¿Me pueden dar un ejemplo?" [can you give me an example?]. Some students provided examples such as: "dos más dos" [two plus two] or "ocho es el doble de cuatro" [eight is twice four]. Ms. Lucía acknowledged students' responses and continued to unpack the problem. Ms. Lucía was asking students to provide the conceptual definition of the

word ‘double’. While it is clear students understand the concept of double, a specific definition was not procured.

In a DLBE classroom, teachers are tasked with teaching to increase students’ access to the language and content. This teaching skill seems to be particularly developed as teachers become more comfortable discovering the nuances of language, and how it is used in academic contexts (de jong & Barko-Alva, 2015). We argue that a purposeful shift in how questions are posed in math classrooms could foster the integration of language and content instruction. For instance, Ms. Lucía could have asked, “¿Quién me puede dar el significado de la palabra *doble*?” [who can provide the meaning of the word ‘double’?]. Thus, by incorporating *meaning* into the question, the teacher is creating opportunities to further explore verbs such as: to ‘define’, to ‘identify’, and to ‘describe’, which will likely reinforce students’ skills in defining specific academic concepts.

Incorporating Language to Create Opportunities for Cross-linguistic Connections

The word “frasco” [jar] was featured in the word problem. She asked, “¿Qué es frasco?” [what is ‘jar’?]. Students proceeded to provide the common English equivalent “jar.” In this particular interaction, the question could have been reframed to signal number and gender. For instance, “¿Qué significa frasco?” [what does ‘jar’ mean?] could have created a teaching opportunity to briefly discuss that the noun “el frasco” [jar] marking its gender and number (i.e., singular and masculine). Ms. Lucía could have then identified connections between the similarities and differences in how Spanish and English signal the use number and gender.

Incorporating Language to Create Interdisciplinary Connections

As Ms. Lucía continued to unpack the problem, she asked, “¿Qué sabes?” [what do you know?]. Had she reframed this question as “¿Qué información nos da el problema?” Or “¿Qué evidencia nos da el problema?” [what information is the problem providing/what evidence is the problem giving us?], Ms. Lucía could have strategically used words such as ‘information’ and ‘evidence’ to highlight cross-disciplinary connections as well as increase student access to cognates. While working on interpreting the decimals represented in the 10-by-10 grids (Figure 1), Ms. Lucía addressed students by asking them the following question, “¿Qué es A?” [what is A?]. This question is quite open-ended (a possible answer would be ‘Una letra.’ [a letter (of the alphabet)]). Ms. Lucía could have followed up by specifying the intended sense of the question with more refined phrasing: A is the label of a grid, and it represents a specific decimal number. Thus, shifting the question to, “¿Cuál es el decimal representado en el diagrama A?” [what is the decimal represented in grid A?] introduces students to the verb “representar” [to represent] and to the noun “grid” [el diagrama], which are found across different academic disciplines (e.g., math, science, social studies, and language arts), thus not only increasing students’ access to common academic collocations, but arguably more importantly, also modeling the importance of refining one’s use of language to more closely fit the thoughts expressed. We conjecture that these categories of teaching moves can vary depending on the part of the lesson the teacher is working on. For instance, in the unpacking part of the lesson, the teacher is focusing more on making sure students understand the context of the problem, and for this reason a focus on vocabulary might be more prominent than during the part of the lesson where the teacher is sharing specific strategies for solving a problem.

Conclusions

The emergent themes highlighted in this work provide concrete examples of how Ms. Lucía could shift her language practices to promote math instruction. As illustrated here, these

questioning strategies could be strategically crafted and formulated to further support dynamic language practices designed to increase students' linguistic repertoires while learning Spanish within the academic context of mathematics (Bunch, 2013). We argue that limiting the complexity of the language teachers use while asking questions during mathematics instruction does not necessarily foster an active bilingual learning environment. We encourage DLBE teachers to plan their lessons including multiple opportunities to integrate language and content instruction as bilingual learners actively negotiate mathematical and linguistic concepts.

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