European Journal of Science and Mathematics Education, 2022, **10**(3), 366-379
ISSN: 2301-251X (Online)

OPEN ACCESS

Research Article

Subtract? That's a Math Word! Unpacking Teachers' Language Choices in Preschool and Kindergarten Classrooms

Gabriela Arias de Sanchez [1,2*]
0000-0003-1408-413X

[1] University of Prince Edward Island, CANADA
[*] Corresponding author: gsanchez@upei.ca

Citation: Arias de Sanchez, G. (2022). Subtract? That's a Math Word! Unpacking Teachers' Language Choices in Preschool and Kindergarten Classrooms. *European Journal of Science and Mathematics Education, 10*(3), 366-379. https://doi.org/10.30935/scimath/11988

ARTICLE INFO

Received: 23 Jul 2021

Accepted: 31 Mar 2022

ABSTRACT

Even though a substantial body of research suggests that adults' math talk fosters children's mathematics development and willingness to learn mathematics, little is known about how teachers make pedagogical decisions to communicate mathematics to young students. Supported by socio-constructivist and semiotic lenses, the study focuses on the close interactions between teachers and their students to better understand the educators' perspectives and the rationale for their mathematical pedagogies when communicating and mediating number sense to young students. An instrumental case study approach and discourse analysis were utilized to investigate how a cultural tool, mathematics, was communicated and mediated to preschool and kindergarten students. Findings indicated that participants focused on supporting young students' meaning-making processes before teaching language form. This pedagogical choice resulted in educators creating a particular early year's mathematical discourse grounded in the avoidance of nouns and in the use of terms that students knew, verbs, and terms that denoted actions.

Keywords: early years mathematics, semiosis, discourse analysis, language choices

INTRODUCTION

During the last decades, research has indicated that mathematical gains of school students are significantly connected to the quality of early mathematics education (Claessens et al., 2013; Clements & Sarama, 2013; Hornburg et al., 2018; Ritchie & Bates, 2013; Watts et al., 2014). Further, research continues to stress that the development of early mathematics skills is strongly influenced by teachers' communication and mediation of mathematical meanings (Carlsen, 2013; Casserly et al., 2015; Chilvers, 2021; Moffett & Eaton, 2018; Purpura & Reid, 2016; Spreckelsen et al., 2019; Wilkinson, 2018).

Supported by socio-constructivist (Mercer, 1995; Vygotsky, 1978, 1987; Wertsch, 1993) and semiotic lenses (Halliday, 1978) the study is built on the concept that language is associated with meanings; thus, having a fundamental role in the construction of knowledge, in this case mathematical knowledge. In that sense, "learning the language of a new discipline is part of learning the new discipline; the learning is not separated from the language that constructs the new knowledge" (Schleppegrell, 2010, p. 79). The study is also grounded in the view that language acquires meaning in context (Vygotsky, 1978, 1987) and that language and contexts are inseparable (Gee, 2014). The intrinsic relationship between meanings and context is, according to Vygotsky (1987), a result of internal transformations that are supported by language and the presence of others, for example teachers.

The study further recognizes that mathematics is "a created world, a world of the human imagination" (Barton, 2009, p. 121) that is also re-constructed and co-constructed in different contexts (for example, the

academic context, the work context, the street context, and the early years context). Therefore, it is valid to consider that there is more than one type of mathematical discourse practice, and that these practices vary socially, culturally, and historically (Arias de Sanchez, 2017; Arias de Sanchez et al., 2018; Barton, 2009; Moschkovich, 2007, 2015).

Despite the fact that a strong body of research suggests that adults' math talk fosters children's mathematics development and willingness to learn mathematics (Anderson et al., 2016; Arias de Sanchez, 2017; Arias de Sanchez et al., 2018; Borden & Munroe, 2016; Casserly et al., 2015; Nunes, 2016; Moffett & Eaton, 2018), little is known about how teachers make pedagogical decisions to communicate mathematics to young students. This study focuses on the close interactions between teachers and their preschool and kindergarten students to better understand the educators' perspectives and the rationale for their mathematical pedagogies when communicating and mediating number sense to young students. The study was guided by the following two questions:

1. How do educators understand and view language in mathematical instruction?
2. How do educators use language when communicate mathematics to young students?

By investigating how educators make choices and use language to mediate mathematics meaning, this study expands current conceptions in early years mathematics teaching. The study also reveals important insights for teachers' mathematical professional development.

METHODS

A preschool and a kindergarten teacher were purposefully chosen (Patton, 2015) from provincial databases to participate in the study. Invitations to participate in the research were sent to schools' principals/supervisors. After principals'/supervisors' approval, invitations were sent only to those educators that held the following criteria:

1. that the educator had at least five years of experience;
2. that the educator taught in an English classroom; and
3. that the educator manifested an interest in mathematics education.

Children between ages 4 to 6 attended the preschool and the kindergarten class. The preschool teacher used a provincial curriculum framework to guide her teaching. In the kindergarten classroom, the teacher followed a provincial integrated play-based curriculum guideline.

An instrumental case study approach (Stake, 1979; Yin, 2015) and discourse analysis (Gee, 2014) were utilized to frame the analysis of language in use (Gee, 2014). Described as a method for studying, exploring, and better understanding how language happens, discourse analysis facilitated the examination of patterns in language (Schleppegrell, 2010) and the exploration of the relationship between language and the early years math classrooms context.

Multiple data sources were collected to develop a thick description (Geertz, 1973) of each of the cases, including an initial interview with each educator (Fontana & Frey, 2000), classroom observations (Angrosino & Rosenberg, 2011), and photographs (Harper, 2000). Additionally, the educators created and participated in five video recording sessions as they taught number sense activities. After the videos were collected, I conducted a video recall session (Dempsey, 2010; Haw & Hadfield, 2011; Lyle, 2003) with each educator in which we watched sections of the video clips together and discussed the teacher's use of language during the number sense activities. Participants were provided with a copy of a transcript of the interview and the video recall session to check for accuracy.

Data Analysis

The initial interview and the video recall sessions were fully transcribed and organized in 75 stanzas. Grounded in Gee's (2014) model for discourse analysis, I used *Conversations* and *Figured worlds* (Gee, 2014, p. 95) as tools of inquiry to build background information for the analysis of language in use. The following questions were adapted from Gee's (2014) framework:

1. What situated meanings do these words and/or phrases have in this stanza?

2. What *Figured worlds* do these situated meanings appear to implicate? and
3. What *Conversations* do these situated meanings appear to implicate?

I then looked closely at the linguistic details of the stanzas and concentrated on how content words (nouns and verbs) as well as function words (articles, pronouns, and prepositions) supported the main claim in each of the stanzas, particularly in relation to mathematics. The analysis also focused on how educators used intonation and stress.

FINDINGS

The findings reported in this study show how Ann and Beth (all names used in this article are pseudonyms), a preschool and a kindergarten educator, respectively, made pedagogical decisions regarding their use of mathematical language when teaching number sense to their students. Both educators had more than 20 years of teaching experience. Ann, the preschool educator, held a certified early childhood diploma; Beth, the kindergarten educator, held a Bachelor degree with a major in psychology, an early childhood certification, and a Bachelor of Education.

Findings are organized within the *Conversations* and *Figured worlds* (Gee, 2014) held by the educators as they taught and subsequently reflected about their mathematical language choices.

For this article, I provide illustrative portions of eight stanzas in four pairs; the first stanza of each pair reports the classroom mathematics activity, and the second paired stanza shares the teacher's reflection on what was going on mathematically and pedagogically at that point in time. Each "in class" stanza has an identification number (for example, stanza 3); the educator video recall session for each stanza is described with the same number and a letter (for example, stanza 3a). I also present a brief description of the classroom environment in which the sessions occurred to allow the reader to understand the context of the interactions.

To facilitate the language analysis, the following transcription conventions from Gee (2014) have been used within the stanzas:

1. A period indicates a final intonation, not necessarily the end of a sentence;
2. Words underlined indicate stress;
3. Words capitalized and underlined indicate higher stress;
4. Two periods indicate a brief pause, less than a second;
5. (0.5 second pause) Numbers in parenthesis followed by the term "pause" indicate silence time in seconds;
6. Bold indicates mathematical register; and
7. Multiple letters indicate an elongation in the speech (i.e., woooord).

Conversations

Within discourse analysis, *Conversations* with upper case C refer to the themes, arguments, or debates that are particular within a group (Gee, 2014). As Gee (2014) pointed out, *Conversations* "are debates in society or within social groups that a large number of people recognize" (p. 222). As early years educators, Ann and Beth believed that young children need to learn mathematics by doing the math. They also agreed that mathematics was meaningful for young learners if students could see and manipulate concrete materials to develop mathematical understandings:

> They [the children] need to be able to see it…they need to be able to have the experience, not just sitting down with paper and pen but to be able to be active, to use manipulatives, and real items (Beth, January 5th, 2015).

In general, early years education is supported by the belief in the importance of learning through exploration, in what is known as "hands-on" discovery learning. Moreover, play and play based-pedagogy are considered fundamental methodologies for young students' meaningful learning (McGuinness et al., 2014; Pyle & Daniels, 2017; Pyle et al., 2018). This *Conversation* was strongly supported by Ann and Beth who

indicated how important it was for them to help their students to link mathematics with real and concrete experiences that they believed could enact students' mathematics meaning-making. As Beth stressed,

> Like learning about 3D geometric shapes, or geometric solids, like we [kindergarten] don't get that…BUT…we paired that with what it is meaningful to us [kindergarten] and we are like "Here is a can, we are talking about cylinders? Here is a can!" …so you know, you try to anchor down those words…It is the best you can do right now, and then as their experiences broaden and all those higher order thinking starts to fall in place for them, they will be like "AHA, now I can make that connection between a can and a 3D shape! (Initial interview, October 7th, 2015).

Participants also adhered to the *Conversation* that mathematics was embedded in the classroom's environment, which in turn they argued, supported students to construct mathematical ideas by problem solving and observing relationships. As Ann stated,

> "Mathematics happens the whole day in our space; for example, the children think they are playing bingo, and they are having so much fun playing bingo, but what they are really doing is matching numbers" (Ann, November 5th, 2015).

Both classrooms had a math center in which students were expected to engage in math explorations by freely choosing mathematics resources and manipulatives; additionally, educators led math instructional time by almost daily introducing a particular mathematics concept through a question, a game, or an activity. During both types of classroom interactions, children-lead and teacher-lead, educators agreed that their role was to guide and scaffold students while using the language of mathematics. Ann and Beth shared the *Conversation* that it was absolutely necessary to

> "Interject that language as much as possible; for example, if a child is building a tower we would just automatically say: Which one is taller? Which one is shorter? We are just used to that, it comes naturally" (Ann, January 10th, 2015).

Of interest were educators' beliefs about what they described as *natural* ways of talking math. Stanzas 6-6a and 1-1a display examples of this argument:

Stanza 6 (in math class)

Lucy and Sara went to the sensory table; the table had beans, a balance scale, and paper bags with a numeral written on each of them. The scale had numbers from 1 to 10. Ann explained that the numeral indicated the weight and that they had to fill the amount of beans which corresponds to this weight. Lucy picked a paper bag with the number eight; Sara started to fill the scale's basket with the beans.

Ann1 : Do you need **more**? Tell her Lucy…

Lucy2 : **mooore**

Sara3 : **Mooore** (she added a few beans)

Ann4 : **Moooore**?

Lucy5 : I am almost done (looking at the number 8on the scale)

Ann6 : Does she need a **lot** or a **few more**?

Lucy7 : Just a **few more** (Sara added a few beans)

Sara8 : Done!

Ann9 : What do you think Lucy?

Lucy10 : Nope, a **few more**…not quite yet

Ann11 : Not quite yet? (Lucy added two beans)

Sara13 : Not yet…

Ann14 : So you need a **couple more**

(Sara added two beans)

Lucy15 : Done!

Stanza 6a (educator's video recall)

Researcher : Tell me about the use of the term "more"

Ann1 : the girls were there… they could see it…

Ann2 : Sometimes we say it

Ann3 : without even thinking…

Ann4 : I guess we want them to understand

Ann5 : the concept of the quantity

Ann6 : We use it a lot,

Ann7 : and children use the word "**more**"

Ann8 : so I think that we [teachers] do a lot from what they [students] say

Stanza 1 (in math class)

Beth and the children sat on the carpet. The educator had a bowl with five real apples; as soon as everybody was quiet, she started with the poem and while singing it she removed the apples from the bowl one by one.

Beth1 : **Five** little apples sitting in a bowl

Beth2 : **One** wanted out and started to roll,

Beth3 : It HIT the table and it hit my feet,

Beth4 : Now…

Beth5 : **how many** apples are there to eat?

Children6 : **Four!**

(The song continued until there were no more apples in the bowl; with every change Beth asked "how many are there now?" and the children responded correctly (three, two, one, zero).

Stanza 1a (educator's video recall)

Researcher : How does math unfold though this video?

Beth1 : I have found that poem…

Beth2 : it was meant…ahm…

Beth3 : It was filling for my literacy time,

Beth4 : it was going to be leading to my literacy time

Beth5 : and the math just unfolded from it…

Beth6 : because they could see the math…

Beth7 : I wasn't expecting all that math talk to happen…No…

Beth8 : so I just kind of rolled with it…

Beth9 : In terms of what to say,

Beth10 : I just went with the flow

Stanzas 6-6a and 1-1a show how *natural* ways of talking mathematics emerged while the educators and their young students appear to have a common understanding about the mathematics domains and the meaning of the language used. Beth talked and questioned students about numbers (up to five), number words, and part-whole relationships; Ann used approximation words (Resnick, 2000) such as "more," "a few more," and "a couple more" to describe the size of quantities. In both cases, the educators shared the perception that students understood the signified meaning these terms carried. Because the *conversation* continued and children did not question the terms, it could be suggested that children were familiar with the language. I contend then that because of this shared understanding, these educators were able to "roll with it" (Stanza 1a) and as Beth stated, just "go with the flow" (Stanza 1a). The language used by the educators focused on ideas and concepts students already knew (for example, number words) and as a result that language became a point of reference (Turnbull & Arnett, 2002) for the task to flow and for the mathematics to emerge *naturally*. Mathematics' *conversations* that involved number sense also flowed naturally when the educators code–switched or mixed words from English and the language of mathematics (Arias de Sanchez, 2018) when they used number words up to 20, and expressions such as "how many," "counting, "patterns," "groups.". They also code-switched to compare sizes, using terms such as "less," "small" "little," "tallest" "shorter," "more," "few," and "biggest."

However, the teachers' *natural* ways of talking math with their students was disrupted when they perceived that the term was too abstract for their young students to comprehend. In a previous article (Arias de Sanchez et al., 2018), I have explained how educators working with young students adhere to the *Conversation* that "the mathematics' register belonged to a mathematics authority outside the classroom that had little to do with the ways math must be delivered in the early years classrooms" (p. 10). Findings demonstrated that Ann and Beth explained that teaching the mathematical meanings carried by abstract mathematical terms was a complex task. The stanzas showed that these educators' perceptions of students' abilities and their view of mathematics as an outside authority, certainly impacted their ways of talking and mediating the math. This *Conversation* aligns with previous research that pointed out the language of mathematics and its register becomes an object of learning that also needs to be taught (Adler, 1999; Herbel-Eisenmann et al., 2015; Moffett & Eaton, 2018; Schleppegrell, 2010; Wilkinson, 2018); this complex pedagogical demand was described by Pimm (1987) as "teaching the language within a language (p. 74). Hence, when Ann and Beth perceived that the terms were too abstract and they have to disrupt the *conversation* to teach the language of math, they oriented their teaching toward simplifying or avoiding the language of mathematics. Claims such as "I don't use the word "less," "half," "equal," or "I have to think about a word for saying that" are evidence of this matter and were common upon the analysis of responses.

Stanzas 14 and 14a displays an example of avoiding the language of math where upon reflection, Ann explained that she was talking about *leftovers* and that mathematics was not involved in the activity. Her reflection appeared to indicate that she saw every day use and meaning, hence she had no intention of portraying the idea of the remainder (the math term /concept) that "leftover" might mean.

Stanza 14 (in math class)

The educator placed plastic fraction pies on the table as an invitation. Susan, Carla, and Mary were breaking the pies and pretending to share slices of pizza; the educator sat with them. Ryan and Mark came

together to the invitation; they started to break the pies and pretended to share slices of pizza. Ryan was sharing the slices of a ¼ pie).

Ann1 : So **one** for Mark and **one** for me.

Mark2 : I want a yellow piece…

Ann3 : **How many** did you have **left over,** Ryan

Ann4 : after you passed them around

Stanza 14a (educator's video recall)

Researcher : It was interesting that you asked students about a remainder…

Ann1 : "**one left over**" wouldn't be something that I put in there

Ann2 : because of being a math term…

Ann3 : I would have picked the expression

Ann4 : because I would have thought

Ann5 : that they can understand that there was something "leftover,"

Ann6 : but not as math term,

Ann7 : It's a leftover,

Ann8 : leftovers, you know?

Ann9 : Not as a math term…

Ann10 : that term is too complex.

Figured Worlds

Gee (2014) describes *Figured worlds* as cultural models or schemas, which are often unconscious and are grounded in social and cultural groups (p. 95). *Figured worlds* capture what is mostly considered to be "typical or normal about people, practices, things or interactions (p. 226).

Ann and Beth grounded their math pedagogy in the *Conversation* that learning mathematics during the early years required children to learn by doing; they also agreed that sometimes, the language of math was not necessarily the focus of instruction. This *Conversation* was evident in statements like the one provided below when Ann (January 25th) reflected about how she talked to students about addition and subtraction,

> "I feel it is more important that they understand the concept [adding and subtracting] than the words… the concept that this many and this many changes the amount when you put them together is what matters…Do they really need to know about minus, and equal?"

The analysis of the stanzas revealed that this *Conversation* sometimes had a clear pedagogical purpose ("I will never say 'fraction'); other times, decisions were made based on what the educators perceived or sensed was best for their students' meaning-making processes. This was the case when the analysis of the stanzas revealed a hidden *figured world* that emerged upon educators' reflections. This *figured world* indicated that educators mostly used "verbs or terms that denoted the action or the actions of doing math" (Author) such as "combining," "making," "putting these groups together," "taking away," "taking," "take," "borrow," "borrowing", "move them here," "counting" "removing" "pulling apart" "breaking" "change," and "changing." Moreover, participants also shared the *figured world* that dismissing the use of nouns was a common and necessary practice when talking math to their young students. Schleppegrell (2010) has discussed how mathematics

entails highly technical language that sometimes encodes processes such as addition and subtraction as things. Interestingly, the avoidance of nouns during early years mathematical interactions analyzed in this study, indicate a pedagogical effort to make mathematics transparent (Adler, 1999) for young students, but also unpacked how a science that is grounded on dynamic relationships and patterns was mediated so it could become meaningful for them. The focus of teaching was on meaning rather than taking on form, which according to Schleppegrell (2010) is "key to all discussions on mathematics concepts" (p. 150).

The presence of this hidden *figured world* is exemplified in the stanzas 11-11a.

Stanza 11 (in math class)

Beth asked the children to show 4 with their fingers

Beth1 : Show me four fingers

(children showed four fingers)

Beth2 : Nick, how are you showing four? (Nick showed three fingers on one hand and three fingers on the other hand; Beth stood up and kneelt down in front of him)

Beth3 : Ok…wait a second…

Beth4 : if I show four like this (she repeated what Nick was doing, 2 fingers and a thumb on each hand)

Beth5 : …let's count…

Nick6 : one, two, three, four, five, six.

Beth7 : oh…we have too many…we have too many

Beth8 : What CAN I DO TO MAKE IT FOUR?

(Nick tucked in one thumb from each hand)

Beth9 : Oh wait…hold on…I am looking at Nick's fingers…

Beth10 : Nick tucked his thumbs in (she repeated the action)

Beth11 : he tucked them in…

Beth12 : How many are there now? Help me to count,

Nick13 : one, two, three, four

Beth13 : Ohhhhh, NOW I have four!

Stanza 11a (educator's video recall)

Researcher1 : Could you explain your use of language during this session?

Beth1 : Mmmm….

Beth2 : I said "IT'S TOO MANY!"

Beth3 : and then I demonstrated

Beth4 : and I said "He TOOK THESE AWAY," in trying to…

Beth5 : 'cause that's one

Beth6 : of those math terms that you have to teach children what that means

Beth7 : …So, I said the words "TOO MANY"

Beth8 : but then I said "and he did this,"

Beth9 : trying to pair a demonstration with the language

Beth10 : in case they did not get what "too many" means…

Beth11 : 'cause it's so hard to EXPLAIN…

Beth12 : because I thought

Beth13 : "well that's language they understand,"

Beth14 : they can say "he TOOK that from me,"

Beth15 : so they understand

Beth16 : what that "took away" phrase means…

Beth17 : so they can see that I am subtracting too…

Beth18 : is language they understand…

Beth19 : they already understand "Oh, she took two."

Researcher20 : Would you have used the word subtract?

Beth21 : No. I was just going to say that.

Beth22 : I would not have used the word subtract,

Beth23 : not in kindergarten…

Beth24 : I think, again,

Beth25 : is one of those words

Beth26 : they need to understand the concept

Beth27 : and then at some point pair that language with it;

Beth28 : but I don't know when that should happen.

Beth29 : … I don't know (pause, 0.5 seconds)

Beth30 : I have never used the word "subtract;"

Beth31 : I could say, "take away, "or "took one,"

Beth32 : But I will never use the word "subtract…"

Beth33 : THAT'S A MATH WORD!

Beth said aloud Nick's actions (excerpt 4, 9, and 11) to explain and orally stressed the mathematical idea that there were "too many" in Nick's representation of four. During the video recall session, Beth explained that because "too many is one of those math terms that you need to teach children what they mean" (excerpt

10), she had to "pair" the language she used (excerpt 9) with actions and her own modeling. Certainly, stanza 11 revealed how Beth provided her students with different representational tools, such as fingers, and her own oral intonation and stress, to help her young students visualize how to make 4, as well as how having more than 4 was having "too many." It could be argued then that Beth's teaching was grounded in the understanding that mathematics' meanings need to be seen and represented and that she believed that mathematical language, although a representational tool itself, needed to be clarified and connected with actions. In this particular case, the use of fingers permitted children (and Beth) to change the combinations quickly (i.e., adding one more finger or tucking one in), and as result, small combinations of numbers were easily counted and subtilized.

During the activity, when Nick tucked his thumbs in, Beth signaled for her student that the group of 6 fingers had changed by asking "how many are there now? (Excerpt 10); later on she also stressed the term "now" to indicate that same change (excerpt 13). Interestingly, although she never used the terms "take away" with her students, she made reference to them during the video recall session to explain her actions during the activity. Beth argued that "taking away," was the right terminology to use because of children's familiarity and understanding of it. Furthermore, Beth also explained that by highlighting that the groups have changed because they were taking away Nick's thumbs, children could see that she was subtracting. However, when the researcher asked Beth about the term subtract, she eloquently said, "Subtract? THAT'S A MATH WORD!" (excerpt 33). Beth seemed to clearly differentiate the science of mathematics and its register as something that exists perhaps far away from her classroom boundaries. Moschkovich (2010) discussed how the view of mathematics as an academic practice that somehow exists in opposition to school classroom practices impacts the pedagogy of mathematics. Definitely, Beth's mathematical teaching practices and the decisions she made about language appeared to be grounded in this belief. In Beth's *figured world* a math term like subtract has neither a place nor meaning in her kindergarten classroom. Moreover, she clearly believed that teaching how sets changed from their initial amount should be understood prior to teaching the term that scientifically represented that type of change.

DISCUSSION

The results of this study are consistent with socio-constructivist and semantic perspectives that view language as a tool that constitutes and is constituted by context (Vygotsky, 1978), in this case the early years classroom context. Hence, participants use of language when communicate number sense to young students was grounded in strong arguments, perceptions, and shared understandings about mathematics and young children's ways of learning. Findings also align with previous research by stressing how language does not exist in isolation, but rather, within a complex network of systems that are intrinsically interwoven in the classroom (Adler, 1999; Levine, 2009; Moffett & Eaton, 2018; Moschkovich, 2015).

The *Conversation* of viewing mathematics and its language as abstract entities certainly contradicted other *Conversations* (such as learning through play) that participants held in relation to teaching and learning. As a result of this perceived dichotomy, I reason that efforts were made by the educators to make mathematics and the language that conveys its mathematical meanings reachable for students. This finding not only shows how the complex relationship between language and mathematics unfolds in the classroom but also reveals how educators' use of language impacted their mathematics' pedagogy. This point is important because Ann and Beth teaching approaches suggest the reliance on a trajectory that focuses on supporting young students meaning making processes prior to teaching language form. Reflections such as "they can make that connection between a can and a 3D shape," "I feel it is more important that they understand the concept [adding and subtracting] than the words," or "they need to understand the concept and then at some point pair that language with it" are evidence of this matter.

Results indicated that as educators and their young students interacted mathematically, the language of mathematics was not static, but rather a dynamic and situated sign system. Situating the math within classroom realities stresses the idea that mathematics is related to context (Barton, 2009; Gee, 2014; Vygotsky, 1978, 1987) and also permits understanding why the participants focused their efforts on making mathematics' signification accessible for students. Ann and Beth talked about the importance of children's active explorations and worked on helping students to interpret math meanings through a variety of

experiences, the use of concrete materials, and the strong consideration of their students' previous knowledge. The cross-case analysis of the stanzas showed that educators hold the *Conversation* that young children needed "to see" the math meanings, which shows their belief in making math reachable for students. In these classrooms mathematical meanings were exposed (so children could see them) through the use of manipulatives, graphics, and visuals, and also through the stress put on the descriptions of their own actions as educators talked math. This pedagogical effort resulted in the creation of a particular discourse for their mathematics classrooms, in which math meanings were carried by terms that students knew (i.e., "more"), actions (i.e., "borrow") and terms that denoted actions (i.e., "pull them together"). In a recent chapter, Borden and Munroe (2016) advocated for the importance of verbified mathematical early years experiences for aboriginal children that focus on the active rather than the static features of concepts (p. 73). Ann and Beth surely seemed to focus on validating their students' ways of learning and talking math; I question then, if a verbified mathematics should not be the focus for all early years math experiences, as doing so seems to be the best way young students learn and think mathematics (Clements & Sarama, 2013; Kotsopoulos, 2007). After all, "Mathematics is really about actions, motions, and verbs" (Borden & Munroe, 2016, p. 73).

That mathematics teacher's talk and the smoothness of interactions with young students were fluid when educators perceived students understood the language involved is consistent with my previous work (Arias de Sanchez, 2017; Arias de Sanchez et al., 2018). Yet, when educators felt that they needed to teach the math but also the language that carries its meaning, their efforts were oriented towards simplifying, avoiding, or as it was indicated earlier, using verbs and action-terms. Analysis indicated that in those situations the smoothness of the *conversation* had to be broken, as carried meanings needed to become "visible" (Adler, 1999) for the children. The educators' efforts seemed to be concentrated on those opportunities as the meaning carried by particular terms was explained, described, and "paired up" with different layers of representation. During those breaks it appeared that the educator's use of language became what Turnbull and Arnett (2002) described as the entrance point for meaning negotiations; Vygotsky (1978) also explained these spaces when he discussed the zone of proximal development and the role of language within the negotiation of meaning. According to Moore (2002), "these negotiations open the path for mutual adjustments" (p. 281) and as he pointed out, some sort of modifications then happened in the flow of the speech and the structure of the *conversation*. I claim that this crisscrossing of language and meaning provided educators with the possibility to make language and pedagogical choices that aligned within the *Conversations* and *Figured worlds* they held in regards to early mathematics learning.

The use of video recall to facilitate the participants' reflections about their use of language, points to the critical importance of educators' thinking about the mathematics meanings carried by mathematics language. Findings revealed that Ann and Beth were involved in complex language decisions as they worked with the children. Claims such as "I have to think about a word for saying that" are evidence of this matter. In order for language to become a meaningful pedagogical tool, educators teaching mathematics to young students need to become aware of the mathematics language trajectories. This in turn, I argue, will support their language decisions. The argument is that "thinking about language might help educators think about the intrinsic relationship between language and mathematical meanings" (Arias de Sanchez et al., 2018, p. 12).

CONCLUSION

The understanding of language as a vehicle of thought and as a vehicle to communicate math meanings has significant implications for educational contexts. Previous studies have indicated that mathematics teaching presents complex linguistic challenges, particularly due to the technicality of the terms that need to be signified by both teachers and students; overall findings have stressed that the more advanced mathematics becomes, the more language dependent it is (Kotsopoulos, 2007; Schleppegrell, 2010). One may think then that mathematics education during the early years should facilitate children's re-constructing and co-constructing math knowledge that begins with their natural abilities and moves to more advanced understanding. I argue that this process of continuous shifting is an educators' responsibility and that educators' professional understanding of the integration of mathematics and language is crucial for the improvement of mathematics learning during its foundational stages. My previous work stressed the presence of semantic patterns between proto-quantitative terms and the mathematics register (i.e., "little"

with "equal") (Arias de Sanchez, 2017; Arias de Sanchez et al., 2018). The current article has further expanded those results by suggesting the presence of semantic patterns between verbs or terms that denote action with the math register (i.e., "taking" with "subtract"). Vygotsky (1978) explained the role of language increased complexity decades ago; I propose a systematic way of looking at language during early mathematics teaching experiences that focuses on a verbified mathematics as a valid way of knowing math. An emphasis on the actions and the action-terms through which mathematics is co-constructed in the classroom could become a key strategy for engaging and scaffolding the youngest students. Moreover, educators' awareness and attention on the actions of math as a starting point for math instruction could result in a transformative approach for overall foundational mathematics teaching. If language is considered as a tool that facilitates the construction of meanings (Vygotsky, 1987), learning to use terms that convey mathematical actions and relationships implies that young students are challenged in the complex process of mathematical interpretations. The development of action-terms trajectories alongside math conceptual trajectories certainly opens great possibilities from a semiotic perspective of mathematics that needs further consideration.

Even though a small sample was chosen for this study, as is the norm in qualitative studies, this investigation has expanded current conceptions of early mathematics teaching. Knowledge translation of this exploration might result in substantive shifts in how educators are trained and develop their professional skills for teaching mathematics to young children. While is beyond the scope of this study to explore this occurrence, further research is needed to investigate the alignment between the trajectories of early years mathematics domains and the trajectories of math language in all domains of early mathematics teaching, including operations, geometry, measurement, patterning, and data analysis and probability. Further research is also needed in regards to investigating teachers' use of verbified mathematical language with older students.

Funding: This study was funded by the Social Sciences and Humanities Research Council (SSHRC) of Canada ref # 767-2014-2665.

Declaration of interest: The author declares no competing interest.

Data availability: Data generated or analyzed during this study are available from the author on request.

REFERENCES

Adler, J. (1999). The dilemma of transparency: Seeing and seeing through talk in the mathematics classroom. *Journal for Research in Mathematics Education, 30*(1), 47-64. https://doi.org/10.2307/749629

Anderson, A., Kim, J. E., & McLellan, S. (2016). Culture and mathematical learning: A case study of South Asian parents and children playing a board game. In A. Anderson, J. Anderson, J. Hare, & M. MacTavish (Eds.), *Language, learning, and culture in early childhood. Home, school, and community contexts* (pp. 142-162). Routledge. https://doi.org/10.4324/9781315686790-8

Angrosino, M., & Rosenberg, J. (2011). Observations on observation: Continuities and challenges. In N. K. Denzin, & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (pp. 467-479*)*. SAGE.

Arias de Sanchez, G. (2017). *Exploring code switching in early number sense activities* [Unpublished Ph.D. thesis]. University of Prince Edward Island, Charlottetown, Canada.

Arias de Sanchez, G., Gabriel, M., Anderson, A., & Turnbull, M. (2018). Code-switching explorations in teaching early number sense, *Education Sciences, 8*(1), 38. https://doi.org/10.3390/educsci8010038

Barton, B. (2009). *The language of mathematics. Telling mathematics tales.* Springer.

Borden, L., & Munroe, E. (2016). Speaking English isn't thinking in English: Exploring young aboriginal children's mathematical experiences through aboriginal perspectives. In A. Anderson, J. Anderson, J. Hare, & M. MacTavish (Eds.), *Language, learning, and culture in early childhood. Home, school, and community contexts* (pp. 64-81). Routledge. https://doi.org/10.4324/9781315686790-4

Carlsen, M. (2013). Engaging with mathematics in the kindergarten. Orchestrating a fairy tale through questioning and use of tools. *European Early Childhood Education Research Journal*, *21*(4), 502-513. https://doi.org/10.1080/1350293X.2013.845439

Casserly, A. M., Tiernan, B., & Moffett, P. (2015). Key vocabulary and supporting strategies for early number concepts. *Reach, 29*(1), 18-32.

Chilvers, D. (2021). *How to recognize and support mathematical mastery in young children's play: Learning from the 'talk for maths mastery' initiative*. Routledge. https://doi.org/10.4324/9780429026072

Claessens, A., Engel, M., & Curran, F. C. (2013). Academic content, student learning, and the persistence of preschool effects. *American Educational Research Journal, 20*(10), 1-32. https://doi.org/10.3102/0002831213513634

Clements, D. H., & Sarama, J. (2013). Rethinking early mathematics. What IS research based curriculum for young children? In D. Lynn (Ed.). *Reconceptualising early mathematics learning* (pp. 121-147). Springer. https://doi.org/10.1007/978-94-007-6440-8_7

Dempsey, N. P. (2010). Stimulated recall interviews in Ethnography. *Qualitative Sociology, 33*, 349-367. https://doi.org/10.1007/s11133-010-9157-x

Fontana, A., & Frey, J. (2000). The interview: From structure questions to negotiated text. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 645-672). SAGE.

Gee, J. P. (2014). *An introduction to discourse analysis*. *Theory and method.* Routledge. https://doi.org/10.4324/9781315819679

Geertz, C. (1973). Thick description: Towards an interpretative theory of culture. In C. Geertz (Ed), *The interpretation of culture* (pp. 311-323). Basic Books.

Halliday, M. A. K. (1978). *Language as social semiotic.* Edward Arnold.

Harper, D. (2000). Reimagining visual methods. In N.K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 717-732). SAGE.

Haw, K., & Hadfield, M. (2011). *Video in social science research*. Routledge. https://doi.org/10.4324/9780203839119

Herbel-Eisenmann, B., Johnson, K. R., Otten, S., Cirillo, M., & Steele, M. D. (2015). Mapping talk about the mathematics register in a secondary mathematics teacher study group. *The Journal of Mathematical Behavior, 40*, 29-42. https://doi.org/10.1016/j.jmathb.2014.09.003

Hornburg, C. B., Schmitt, S. A., & Purpura, D. J. (2018). Relations between preschoolers' mathematical language understanding and specific numeracy skills. *Journal of Experimental Child Psychology*, *176*, 84-100. https://doi.org/10.1016/j.jecp.2018.07.005

Kotsopoulos, D. (2007). Mathematics discourse: It's like hearing a foreign language. *Mathematics Teacher, 101*(4), 301-305. https://doi.org/10.5951/MT.101.4.0301

Levine, G. S. (2009). Building meaning through code choice in second language learner interaction: A D/discourse analysis and proposals for curriculum design and teaching. In M. Turnbull, & J. Dailey-O'Cain (Eds.), *First language use in second and foreign language learning: Intersection of theory, practice, curriculum and policy* (pp. 145-162). Multilingual Matters. https://doi.org/10.21832/9781847691972-011

Lyle, J. (2003). Stimulated recall: A report on its use in naturalistic research. *British Educational Research Journal, 29*(6), 861-878. https://doi.org/10.1080/0141192032000137349

McGuinness, C., Sproule, L., Bojke, C., Trew, K., & Walsh, G. (2014). Impact of a play-based curriculum in the first two years of primary school: Literacy and numeracy outcomes over seven years. *British Educational Research Journal, 40*(5), 772-795. https://doi.org/10.1002/berj.3117

Mercer, N. (1995). *The guided construction of knowledge*: *Talk amongst teachers and learners.* Multilingual Matters.

Moffett, P., & Eaton, P. (2018). The impact of the promoting early number talk project on the development of abstract representation in mathematics. *European Early Childhood Education Research Journal, 26*(4), 547-561. https://doi.org/10.1080/1350293X.2018.1487166

Moschkovich, J. N. (2007). Examining mathematical discourse practices. *For the Learning of Mathematics, 27*(1), 24-30.

Moschkovich, J. N. (2015). Academic literacy in mathematics for English learners. *The Journal of Mathematical Behavior, 40*, 43-62. https://doi.org/10.1016/j.jmathb.2015.01.005

Moschkovich, J. N. (Ed.). (2010). *Language(s) and learning mathematics. Multiple perspectives and directions for research*. Information Age Publishing.

Nunes, T. (2016). What is involved in modeling the world with mathematics. In A. Anderson, J. Anderson, J. Hare, & M. MacTavish (Eds.), *Language, learning, and culture in early childhood. Home, school, and community contexts* (pp. 180-196). Routledge. https://doi.org/10.4324/9781315686790-10

Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice*. SAGE.

Pimm, D. (1987). *Speaking mathematically: Communication in mathematics classrooms.* Routledge.

Purpura, D. J., & Reid, E. E. (2016). Mathematics and language: Individual and group differences in mathematical language skills in young children. *Early Childhood Research Quarterly*, *36*, 259-268. https://doi.org/10.1016/j.ecresq.2015.12.020

Pyle, A., & Daniels, E. (2017). A continuum of play-based learning: The role of the teacher in play- based pedagogy and the fear of hijacking play. *Early Education and Development, 28*(3), 274-289. https://doi.org/10.1080/10409289.2016.1220771

Pyle, A., Prioletta, J., & Poliszczuk, D. (2018). The play- literacy interface in full-day kindergarten classrooms. *Early Childhood Research Journal, 46*(1) 117-127. https://doi.org/10.1007/s10643-017-0852-z

Resnick, L. B. (2000). Developing mathematical knowledge. *American Psychologist, 44*(2), 162-169. https://doi.org/10.1037/0003-066X.44.2.162

Ritchie, S. J., & Bates, T. C. (2013). Enduring links from childhood mathematics and reading achievement to adult socio economic status. *Psychological Science, 24*(7), 1301-1308. https://doi.org/10.1177/0956797612466268

Schleppegrell, M. J. (2010). Language in mathematics teaching and learning: A research review. In J. N. Moschkovich (Ed.), *Language and mathematics education: Multiple perspectives and directions for research* (pp. 75-112). Information Age Publishing.

Spreckelsen, M., Dove, E., Coolen, I., Mills, A., Dowker, A., Sylva, K., Ansari, D., Merkley, R., Murphy, V., & Scerif, G. (2019). Let's talk about maths: The role of observed "maths-talk" and maths provisions in preschoolers' numeracy. *Mind, Brain, and Education, 13*(4), 326-340. https://doi.org/10.1111/mbe.12221

Stake, R. E. (1995). *The art of case study research*. SAGE.

Vygotsky, L. S. (1978). *Mind and society: The development of higher mental processes.* Harvard University Press.

Vygotsky, L. S. (1987). *Thinking and speech.* Plenum Press.

Watts, T. W., Duncan, G. J., Siegler, R. S., & Davis-Kean, P. (2014). What's past is prologue: Relations between early mathematics knowledge and high school achievement. *Educational Researcher, 43*(7), 352-360. https://doi.org/10.3102/0013189X14553660

Wertsch, J. V. (1993). *Voices of the mind.* Harvard University Press. https://doi.org/10.2307/j.ctv1pncrnd

Wilkinson, L. C. (2018). Teaching the language of mathematics: What the research tells us teachers need to know and do. *The Journal of Mathematical Behavior, 51*, 167-174. https://doi.org/10.1016/j.jmathb.2018.05.001

Yin, R. K. (2105). Case studies. In J. D. Wright (Ed.), *International encyclopedia of the social & behavioral sciences* (pp. 194-201). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.10507-0