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Code-Switching Explorations in Teaching Early Number Sense

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Abstract: New semiotic perspectives about the role of language in mathematics education indicate that teachers have a fundamental role in communicating and teaching the language that carries mathematical meaning. However, little is known about how educators of young children understand and use the language of mathematics. This study addresses this void. Supported by the understanding that mathematics has its own language (Pimm, 1987), the study focuses on code switching—the mixing of words from two languages—by educators as they shift between the language of instruction and the language of mathematics. A qualitative multiple case study approach utilizing discourse analysis was used to explore three early years teachers' math talk. Findings indicate that these educators code-switched to the mathematics register when they talked about numbers, number words and counting, to revoice students' ideas, to explain students' and teachers' actions, to provide new math information, and when they chose between two terms that belonged to the math register. Findings also demonstrated that educators preferred to avoid the use of the mathematics' register and relied instead on what the educators called "familiar language." Findings further indicated the presence of semantic patterns between perceptual terms and the mathematics register.

Keywords: early mathematics education; code switching; discourse analysis; mathematics register

1. Introduction

During the last decade, a new understanding of the important role that language plays in the teaching and learning of mathematics has emerged [1–3]. From this emerging perspective, language is considered not simply as a way to teach mathematics, but as a means to construct mathematical meaning. This semiotic line of thought indicates that teachers' mathematics talk has a fundamental role in communicating and teaching the language that carries mathematical meanings. However, little is known about how educators of young children understand and use the language of mathematics. Addressing this gap and investigating how much and why educators switch between the language of instruction and the language of mathematics is the main purpose of this study. In particular, the study focuses on code switching—the mixing of words from two languages [4–7]—by educators as they shift between the language of instruction and the language of mathematics.

The study examined early years educators' teaching of number sense, with a focus on their perceptions and on their use of the language of mathematics. Number sense is a foundational strand in early mathematics education and develops as children "understand the size of numbers, develop multiple ways of thinking about and representing numbers, use numbers as referents and develop accurate perceptions about the effect of operations on numbers" [8] (p. 80). Within the study contexts, number sense is a key strand in the curriculum used by the participants and focuses on students exploring the nature and uses of counting, ordering, and comparing whole numbers.

We addressed the following questions: (a) How do educators understand and view language in mathematical instruction? and (b) How and why do educators code-switch between the language of instruction and the mathematics' register?

Recent research suggests that improvement in individuals' numeracy skills correlates with strong early mathematics education. Moreover, numeracy proficiency was recently highlighted as a crucial skill needed for 21st century learners [9]. Therefore, this study relates directly to a major concern in relation to the pedagogy of early years mathematics education. By illuminating the educators' use of language while teaching number sense, this study will help researchers and educators to better understand what impact language and code switching might have on early years mathematics education.

2. Theoretical Perspectives

This study is informed by socio-constructivist and socio-cultural theories which propose that language acquires meaning in context and that language and context are inseparable [10–12]. Vygotsky (1978; 1987), explained that human perception is linked to language and that it is associated with meanings (p. 33). Above all, Vygotsky conceived language as a meaning-making tool and as a mediator between the individuals' physiologies, and socially and culturally produced tools (such as the numeric system); cultural tools, he argued, transform the individual psychological system. For Vygotsky, language and thought are inseparable.

From this theoretical perspective, then, language is more than a tool for representation and communication; "language is a tool for thinking, for connecting, and for constructing knowledge" [13] (p. 76). We also understand that within the intrinsic relationship that exists among language, social practices, and context, particular discourses emerge (i.e., the classroom discourse) [3,14] and we concur with Gee [15] in understanding that a discourse is more than language as it integrates people's ways of talking, knowing, and believing. To that end, we propose that there is more than one type of mathematical discourse practice, and that these practices vary socially, culturally, and historically [16].

2.1. Language and Mathematics Teaching

According to Mercer [17], one of the goals of education is to get students to develop new ways of using language. If language plays a fundamental role in concept development, educators should guide their students to learn new ways of "talking, writing, and thinking" [18] (p. 83). As Scheleppegrell [13] indicated, "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" (p. 79).

We understand language as a tool that communicates and mediates mathematical meanings. The study addresses both these aspects and considers them as intrinsically related. We describe the *language of instruction* as the language (English, in the case of this study) used in the classroom to communicate, explain, justify, define, represent, and ask about mathematical meanings; for example, "How did you solve the problem?" Besides using English terms in the classroom to communicate and mediate mathematics, we suggest that teachers also must teach (and use) the language proper to mathematics. In other words, they have to teach and use a "language within another language" [19] (p. 74). Supported by Pimm's leading work on mathematics' language, we understand that the language of mathematics implies the consideration of the mathematics register as well as everyday and protoquantitative mathematical terms. The *mathematics register* refers to particular terms, and ways of knowing and thinking used to express mathematics [19] (p. 76), for example "parallelogram" and "equal". In general, the mathematics register has been described as comprising precision in arguments, and a tendency toward abstraction and generalization. On the other hand, *everyday mathematical terms* allude to expressions that are used in everyday experiences but that have a particular meaning in the classroom mathematical discourse; for example, terms such as "cancel," and "table," could be considered within this category [20]. Additionally, and supported by Resnick's [21] ideas about protoquantitative mathematics, we describe *protoquantitative terms* as those non-numerical words used to express quantitative judgments; for example, "lots," and "little."

2.2. Code Switching and the Language of Mathematics

Our argument about the coexistence of the language of instruction and the language of mathematics within the math classroom discourse guided our interest in exploring the construct of code switching. We drew upon a body of work on code switching undertaken primarily from linguistic, sociolinguistic and pragmatic perspectives, particularly in relation to second language instruction and learning [4,22]. Researchers conducting these studies argued that code switching results in activating two symbolic forms that challenge individuals to think not only about words but also about meanings. We also drew upon work that examined code switching in mathematics in adult learning and teaching contexts where teachers and students spoke more than one language [23–25]. We understand that although code switching between the language of mathematics and the language of instruction has been previously explored in pre-service teachers' classrooms [26] and within high school mathematics [20] it has not been explored in mathematics teaching with young children.

3. Methods

We used purposive sampling [27] to invite a preschool, a kindergarten, and a grade one educator to participate in the study. To understand in depth the language used by the three educators, we adopted a qualitative multiple case study approach [28]. Each of the classrooms where the case study took place was conceived as a bounded system [29] that framed the use of spoken language in a particular time and space. Therefore, the exploration of the cases was instrumental in nature [30] as each of the classrooms was an enclosed space that provided insight into the educators' spoken language during number sense activities.

The educators' use of spoken language was analyzed through discourse analysis. We employed Gee's [15] approach to discourse analysis and embraced his idea of discourse analysis as "a continuous back and forth between context and language" [15] (p. 36). We contended that by closely looking at, and by investigating the relationship between language and classroom contexts, we were able to better understand the meaning of educators' math talk "in actual contexts of use" [15] (p. 211).

School principals, teachers, and parents gave their informed consent before they participated in the study. The study was conducted within the principles of the Tri-Council Policy Statement (TCPS): Ethical Conduct for Research Involving Humans. The protocol was approved by the University of Prince Edward Island Research Ethics Board (project identification #6006157).

Data Collection and Analysis

During a one-month period in each classroom, the first author observed the classroom contexts and interviewed the educator. Class observations focused on the classroom space, the children, the educators' professional background, and the classroom dynamic, including the mathematics within the classroom, the pedagogy of mathematics in the classroom, and the educator's use of language in the mathematics class. A structured interviewing approach was developed [31] for the initial interview. Questions were outlined to explore background information [15] about the educators' understanding and views about language in mathematical instruction.

After the initial individual interviews, the first author video-recorded 5 number sense lessons that each educator planned and carried out. The video-clips, which we deemed most pertinent to the teacher's use (or lack) of the mathematics register, were selected; these ranged in length from 30 s to 90 s. The first author then conducted a video-recall session with each of the educators; 15 video clips were selected from preschool, 15 from kindergarten, and 14 from the grade one video recordings. During the video-recall session, the educator and the first author viewed the clips together. After the viewing, the first author prompted the educators with a series of questions framed to examine the educators' understandings and views of their use of language, as well as to investigate educators' awareness of how and why they code-switched between the mathematics' register and the language of instruction. Besides these protocols, educators freely expressed their points of view regarding what they saw or heard in the video clips. Each video recall session lasted for approximately 90 min.

The classroom contexts were analyzed through an instrumental case study approach [30]. We first explored each case study separately and then conducted a cross-case analysis to investigate how the educators viewed and used language in their mathematics lessons. To afford a closer look at the educators' use of language, we organized the data into observations that included the selected video recorded sessions and the aligned video recall interviews. We conducted discourse analysis on 88 stanzas. The entrance point of the discourse analysis was the situated meanings [15] of terms and phrases used, as each of the educators taught and talked number sense to their young students. The unit of analysis was language-in-use [15], that is, language that was fully embedded within classroom practices. Words were then conceived as having a situated meaning [15] that was particular to the contexts of each of the classrooms where we conducted the study. In other words, the situated meanings of words and phrases used in a math classroom became a venue to analyze language, but also to better understand the practice of teaching mathematics to young children. We adopted some of Gee's tools of inquiry and focused on intertextuality (words or texts individuals often allude to, that have been said or written by others); figured worlds (cultural models or schemas, which are often unconscious and are grounded in social and cultural groups); and what Gee describes as big "C" Conversations (themes, arguments or debates that are particular from a group).

4. Findings

We provide the reader in the text that follows with some excerpts of the observations that include stanzas from the video clips and the video recall sessions. The stanzas from the video clips have been numbered (i.e., Stanza 1) and the stanzas of the video recall sessions that aligned with the video clip received a number and a letter (i.e., Stanza 1a). To facilitate analysis, we have used numbers to indicate lines and pseudonyms to identify a child; a group of children is identified as "Ch." Educators are identified with the letter "E" followed by a letter that indicted their class level; therefore, EP indicates the educator from preschool, EK the educator from kindergarten, and EG the educator from grade one. The researcher is identified as "R."

In the stanzas, we adapted the following transcription conventions: (a) A period indicates a final intonation, not necessarily the end of a sentence; (b) Words underlined indicate stress; (c) <u>Words</u> capitalized and underlined indicate higher stress; (d) Two periods indicate a brief pause, less than a second; (e) Numbers in parenthesis followed by the term "pause" (0.5 pause) indicate silence time in seconds; (f) bold indicates mathematical register; and (g) Multiple letters indicate an elongation in the speech (i.e., wooooord).

We have organized the findings under three main headings: (1) Educators' understandings and views about language in mathematics teaching; (2) Code switching between the language of instruction and the mathematics' register; and (3) Language choices.

4.1. Educators' Understandings And Views About Language in Mathematics Teaching

The three educators had between 22 and 25 years of teaching experience. The kindergarten (K) and the grade one (G1) teachers both had a university degree, while the preschool (Pre-K) teacher held a provincial early childhood certification.

The three teachers recognized that they needed to scaffold their students' mathematical ideas to achieve further school mathematics learning. They believed in the value of "hands on learning" when teaching mathematics and saw teacher talk as "absolutely necessary" to expose students to the science of math. However, it was evident through the analysis of the interviews and the stanzas, that these educators saw mathematics and the mathematics' register as a complex and abstract entity. As the kindergarten teacher stated, "Even as an adult learner I do not always understand the far-reaching tentacles of mathematics (laughing) ... it's sooo vague and we don't really know what that means ... "

The educators agreed that mathematical meanings were sometimes hard to explain and that it was very difficult to teach the meaning and the language of particular math ideas. The following excerpts in Tables 1–3 show examples how these educators talked about the meaning of equality:

Table 1. Preschool.

Stanza 8 (in math class)	**Stanza 8a (educator's video recall)**
Mike had to count how many people were in class. Mary had previously counted clothes pins with the children's names; Mary had counted 13 names. EP1: Ok, we need to count thirteen heads. EP2: Let's count ... Ch3: **one, twooo, three, four, fiiiive, six, seven, eight, nine ten, eleeeeven, tweeelve, <u>thirteen,</u> ... <u>THIRTEEN!</u>** EP4: **Thirteen**!! Is it the **same**? Ch5: <u>YES!</u>	R: Could you have use the term equal instead of "the same"? EP1: I wouldn't use "**equal.**" I wouldn't, EP2: I just would never use it because you have to go with the language they understand EP3: Later on I am not sure ... EP4: it's certainly something to think about ...

Table 2. Kindergarten.

Stanza 4 (in math class)	**Stanza 4a (educator's video recall)**
The teacher and the children were working in small groups. Children were creating masks and gluing different number of paper noses, eyes, and teeth depending on how many they got when they rolled the die. EK1: **how many** teeth do you have? (pointing at the mask that Sean had created) Sean2: **two** EK3: Danny has **two** teeth EK4: and you have **two** teeth EK5: <u>NOW</u> you have something that is <u>THE SAME</u>! Joanna6: I have <u>**ONE**</u> tooth EK7: just like Emma, EK8: you have **one** tooth and she has **one** tooth EK9: .. that's the same!	R: Could you explain the use of the term "the same" in the clips? EK5: So I think it is EK6: one of those words EK7: that I'm always trying EK8: to have the visual to pair with so ... so ... EK9: because it is really hard to explain EK10: what "the same" <u>meeeeans</u> ... R11: Is it "the same," or is it "**equal**?" EK17: I will use the word "the same" EK18: rather than "**equal,**" EK21: "same" is ... is a word EK22: that they get, they understand ... EK36: when we are making **groups** EK37: that are numerically **equivalent** EK38: I will use "the same" rather than "equal.." ... EK44: what I probably should have said was EK45: "make the same **NUMBER** in your **group**."

Table 3. Grade 1.

Stanza 4 (in class)	**Stanza 3a (educator's video recall)**
During morning meeting the educator brought a scale and manipulatives. EG31: Ok, I have **five** here and I have **four** here (pointing at each side of the scale) EG32: it's almost balanced . . . (she dropped one more block on the side that had 4) EG33: **Five** and **five**. EG36: are they balanced now? Mary37: pretty much. EG38: Ok, if it is balanced, EG39: what do we know about those **numbers**? EG40: They are the.Claire41: **Equal**. EG42: They are **equal**, what's another WORD for **equal**? Matt43: **same**. EG44: **SAME**! Exactly! EG45: THAT'S THE WORD I am thinking about! EG46: If it's **equal** IT IS the same.	R: Was that the first time you were showing them the relationship between equations? EG6: Yes R7: What do you think about the language you use? EG17: like in my mind, EG18: the word "**same**" EG19: it's an easier term EG20: because they can transfer that term "**same**" in so many different ways, you know? EG21: Not just in math but also in other ways EG22: I think lots of them DO understand what "**same**" means, EG23: and could make that connection EG24: between "**same**" and the term "**equal**" in math.

In these excerpts the three educators clearly stated the rationale of their language choices. The stanzas indicate that they avoided the term equal, and even though the idea of "the same" does not necessarily mean that number combinations are equal, the educators wanted students to think about equal as a relationship that means "the same". The teachers' statements certainly align with their beliefs about children learning math from meanings that they already knew. However, the PreK and K examples seemed to contradict the teachers' beliefs about scaffolding students' learning, as they seemed to agree with the idea of challenging young students to think about numeric relationships but not with the use of the language that conveys that meaning.

The analysis showed that similar discussions emerged when the teachers provided a rationale for using the term "number" instead of "digit," "groups" instead of "sets," and the expression "number sentence" instead of "equation". Overall, the analysis shows that to communicate mathematical meanings, these educators used English terms that they believed were familiar to children, or that they thought children already knew. This finding also revealed that teachers' language choices were based on their figured worlds about what young children knew and were capable of understanding.

In some cases, teachers explained that teaching the language of math was *not* a priority, and that their teaching was mostly focused on students coming to understand the meaning of math concepts. Furthermore, teaching the language of math implied having to do "lots of teaching" because the language was hard to explain since their young students did not have any experience with it (and yet in Table 3, the child "volunteered" the word "equal" (Claire41). Hence, teaching the math register was perceived as a complication: "We are doing it [the math]," claimed the PreK teacher, "we are just not saying the words". Surely, the focus was on children experiencing math through different layers of representation, though the mathematics register was conceived somehow as separated from it. The analysis shows that within their complex processes of language decision-making, these educators often decided that to avoid students' confusion, they focused on "building up" from what they believed students already knew. Table 4 from a video recall session, is an example of this idea:

Table 4. Kindergarten.

Stanza 2c
R3: Is it important that at some point a teacher starts saying "**sets**?"
EK5: I think at some point
EK6: children will have to be able to understand
EK7: that **sets** and **groups** mean the same thing . . . you know?
EK8: ..I think that's important..
EK9: that children need to learn that..
EK10: <u>WHEN</u> children need to learn that?
EK11: I don't know..
EK12: But for me right now...
EK13: I want them to understand these dots we are looking at
EK14: so, "**groups**" is a familiar word, so I can use it
EK15: and I don't have to do a lot of teaching before I teach about the dots.

4.2. Code Switching Between the Language of Instruction and the Mathematics Register

It seemed obvious to expect that in school mathematics activities, educators were going to talk mathematically and use the particular register that carries mathematics meanings. Hence, drawing from the theoretical idea of code switching, the purpose of this study was to explore how and why switching to the math register happened, and how the mathematics register entered the educators' talk.

The analysis of the stanzas revealed that when teaching number sense activities these teachers code-switched to the mathematics register when:

(a) they talked about numbers and used expressions such as "how many," "how many more," "count," "counting," "counting on," "amount," and "number combinations" (used only by E1);
(b) they talked about number words such as "one," "two" "ten;"
(c) they compared sizes, amounts, and weight and used terms such as "more than," "less," big," "small," "more" "heavier," lighter," "tallest," and "shortest;"
(d) they talked about regularities and used the term "pattern;"
(e) they talked about "groups;"
(f) they brought a lesson to closure (i.e., "That's a pattern!" "This is called counting forwards"); and
(g) when E1 (the grade 1 teacher) talked about sets and changes in a set, and used terms like "division," "addition," "subtraction," "equal," "double," "take away," "plus," "number sentence," "equation," "equal to," "two numbers that make," "combination for what number?"

In all these instances of code switching, the teachers' use of the mathematics register was effortless, and the dialogue with the students continued smoothly. Overall, educators' perceptions about their young students' prior experiences impacted the ways the math register entered those conversations.

Our analyses also showed that in other code-switching opportunities the smoothness of the conversation had to be broken, as carried meanings needed to become "visible" [23] for the children. In those circumstances code switching was observed when the teachers:

(a) Re-voiced students' ideas (i.e., "when I am counting this way, I am counting forwards");
(b) Explained and then checked students' actions and thinking (i.e., "you are thinking-ten");
(c) Explained their own actions (i.e., "Should I cut this one in half?");
(d) Used contextual clues (i.e., "Daniel is saying that he saw a square to count four";
(e) Provided new math information (i.e., "This is called making ten"); and
(f) Chose between terms that belonged to the math register (i.e., "When you were making the patterns—the groups with your counters, were some groups easier to make than others?).

Some of these instances of code switching align with previous studies where code switching was investigated in English as Second Language classrooms [18,22–25]. Similar to those studies, the mathematics register entered the conversations through what Moore [32] described as a semantic break. In Table 5, we provide the reader with an example of code switching in which we analyzed how the semantic break occurred:

Table 5. Kindergarten.

Stanza 14 (in math class)	**Stanza 14a (educator's video recall)**
Five children were asked to stand up in a row. Each child held a poster with a number (from 1 to 5) written on it. EK1: ah . . . I want to ask you, EK2: what **number** comes after **one**? Ch3: **tttwoooo**.. EK4: what **number** comes after **four**? (pause, 0.5) Ch5: **fffive** EK6: **ffffive** . . . that's right... EK7: When I say after I mean . . . EK8: If I am talking about what **number** comes after **four** (touching the head of girl that had number 4) EK9: it means what **number** comes next (touching the head of the girl that had number 5) EK16: Now, here is a new word, EK17: what **number** comes BEFORE **three**? (touching the head of the girl that had number 3) (pause, 0.6) Sam and Lucy18: **ttwooo** EK19: **Two**, that's right, EK20: that means what **number** do I say **first**; EK21: I say **two** and THEENN I say **three**. EK22: What number comes before **two**? (touching the head of the boy that had number 2) (pause, 0.5) EK23: Anybody knows? Connor24: **One** EK25: yeah, **one**.. EK26: I say **one first** and THEENN I say **two**.	R: Could you tell me more about this scenario? How does your talking help children to understand the idea of the "number after?" EK1: Yeah . . . "before" and "after" EK2: it's like...(laughing) EK3: Because now, I have changed that terminology EK4: because that didn't stick EK5: . . . they are like "Ah? Ah? We don't know what she is talking about" EK6: So I thought, EK7: "Ok, using what comes **first**, what comes next.."

In Table 5, the teacher's focus was the sequence of numbers from 1 to 5; she began by using the terms "after," and "before" to connote the sequence and what comes after a number when counting. At the beginning of the session, she asked the students about a number that was positioned "after" a given one (stanza 14, EK2, EK5). Having the possibility of seeing numbers in the number line, as well as observing the teacher when touching the head of the student who held "the right number," certainly seemed to help the children answer confidently and correctly (stanza 14, Ch3, Ch5). During these first minutes of the session, code switching happened naturally as the teacher and the children showed an understanding of the number words from one to five. As the session unfolded and in an effort to make the meaning of the cardinal relationship between numbers transparent for her students [16], the teacher chose the term "next" to explain the idea of the number "after."

In the second part of the lesson, the teacher wanted the students to focus on the number that was positioned "before" a given one. In the case of Stanza 14, "before three" implied the number that was positioned in the number line that the children were observing (two) as well as the cardinal relationship that involved one, two, three, four, and five. She produced a break in the flow of the activity by stating that they were going to learn a new word (stanza 14, EK16, EK17). The focus of the lesson towards language was then made explicit to the students. This time, even though the children were seeing the numbers in the number line and observing the teacher touching the head of the student that held "the right answer" (stanza 14, EK17, EK22, and EK27), the children seemed more uncertain about their responses (they took longer to respond). After looking for signs of comprehension and observing her student's faces and silence, the teacher provided explicit examples such as "I said two and THENN I say three" (stanza 14, EK21) to explain the meaning of "before." It was not until the end of the session (stanza 14, EK26, EK29) that she code-switched to the math register and used the term "first" to explicitly tell the numbers' ordinal relation in the final example she provided for her students.

We conclude that in examples such as the one displayed in Table 5, the semantic break produced a modification in the flow of the speech and the structure of the conversation [32]. Reflecting about these semantic breaks and code switches could provide educators with a viable and strong pedagogical tool that might assist them to consciously elaborate and use terms in their mathematics practices.

4.3. Language Choices

The cross-case analysis shows that these three educators decided on different language choices as they talked to their young students, and that within those choices they chose to switch or not to switch to the mathematics' register. We draw the idea of "to switch or not to switch" from Adler [23] (p. 25), who explained that math teachers in English as Second Language (ESL) classes faced this dilemma when they debated about ensuring students' English proficiency versus assuring students' mathematics understanding. Although our study was conducted in monolingual classrooms, the similarities with Adler's findings are striking, as the three teachers explained that they often faced the dilemma of deciding between using the mathematics register or ensuring that their young students understood a particular mathematics concept. In Tables 6 and 7 we provide two examples of educators' language choices:

Table 6. Preschool.

Stanza 1 (in math class) The educator gathered the group and explained that Julie brought a treat (a rice crispy square) that she would like to share with all her friends. EP21: **How many** people can have a piece if I just cut it in **two**? Ch22: **Two** . . . EP23: Only **two** people EP24: Oh . . . Is there **more than two** people? Ch25: Yeah . . . EP26: What do you think I should do now? EP27: We'll cut this side on **half** and . . . should we cut this **one** on **half** too? Ch28: Yes! EP29: **How many** are we going to have now? Lucy30: **Fifteen**! EP31: **How many** friends do I have? Samuel32: **One, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen!** (he touched each child) EP33: Would these pieces fill **fifteen** people? Ch34: No EP35: What should I do? Ch36: Cut it! EP37: Cut them in **half**? Ch38: Yes! EP39: Is this **half**? (Making a knife mark through half) Ch40: Yes!	**Stanza 1a (educator's video recall)** R: How does mathematics language unfold through this clip? **Stanza 1c** EP1: I also said "**half**," EP2: but I didn't say "**quarter**," EP3: because I didn't feel . . . EP4: because if they got "**half,**" that's good EP5: because some kids would have experience with "**half**," EP6: like "do you want **half** an apple?" EP7: With "**quarter**?" mmm . . . EP8: If I put it in, I will . . . consciously put it in. **Stanza 1d** R: How do you make those decisions? EP1: I think I am aware of the language that I am using . . . EP2: and I try not to go above their level; EP3: I try to be sure I am down at the level where they are.

Table 7. Grade 1.

Stanza 1 (in math class)	Stanza 1b (educator's video recall)
The teacher placed a printed worksheet on the white board entitled "Fact family cones." The worksheet displayed four columns and four rows of empty squares and a picture of an ice cream cone below each column. In the worksheet, each ice cream cone had 3 numbers. At the bottom of the sheet there were 16 equations for addition and subtraction that matched up with the numbers of the four ice cream cones. EG1: Ok grade one, EG2: you are going to take a look, EG3: there are all kinds of **number** sentences or **equations** that are down here, EG4: and you need to figure out EG5: what **four equations** or **number** sentences EG6: are going to fit and match up with each cone ok?	R: As you know, I will be investigating how teachers switch between the language of instruction and the language of mathematics. How do you see that switching happening in this video clip? EG1: That was a conscious choice.. EG2: I was consciously trying EG3: to make that connection EG4: between the terms "**number** sentence," and the term "**equation**." R5: Do you think that the term **equation** . . . EG6: I feel it's a higher level . . . R7: Could you explain please? EG8: I don't know . . . (pause, 0.3) EG9: I think . . . EG10: they understand the term "sentence," EG11: and we've used the simple terms like "**number sentence**," EG12: we've used it soooo much . . . EG13: now, I think that the term "**equation,**" EG14: is just a **bigger word**, you know? EG15: Just even to get your tongue around EG16: to even say "**e-qua-tion,**" EG17: that articulation of the word **equation** . . . EG18: for them to say it, and hear it, EG19: and remember it, and understand it . . .

Overall, the analysis indicated educators' language choices were strongly rooted in their perceptions of children's previous experiences with math and with the math register, their view of mathematics and its register as an abstract entity, and their view about young children's abilities and English vocabulary limitations. In general, the analysis of the stanzas revealed that the preschool and the kindergarten educators expressed a preference to avoid the mathematics register (i.e., "I don't know if you noticed but I didn't say quarter") while the grade one educator believed that it was necessary to code-switch to the register, but mostly to move students back and forth between the math register and everyday terms with which students had prior experience.

In the instances in which the educators' language choices led to the avoidance of the math register, mathematics entered the conversations through educators' code switching to:

(a) protoquantitative terms [19] (i.e., "a little more");
(b) everyday language (i.e., How many we will need to *borrow* from that five to make that nine a ten?"); and
(c) the educators' explanation of how mathematics happens (i.e., "a pattern repeats over and over again").

Overall, the decision of "not to switch" [23] (p. 25), led to these educators' extensive talk as they tried to describe the mathematics involved without using the register.

The three educators who participated in the study expressed their view of the language of mathematics as being an abstract and extremely complex entity. This was mostly evident during the interviews with the preschool and the kindergarten teacher who argued that their students' ages and their cognitive development were certainly obstacles to comprehending such abstraction. In particular, the three educators held the view 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 classroom. Hence, code-switching to terms they identified as familiar appeared to be used by these teachers to bridge the outside mathematics with their students' language experiences, and as such, protoquantitative and everyday terms emerged as valid language tools. Previous researchers [20,26] have indicated the view of everyday language in upper grade school settings as informal and somehow not fully developed. Hence, we ask that in the dilemma of helping students to move along this journey and towards the use of the register (to develop math competency), should young students' previous math knowledge and use of language be considered informal? If language is a tool that facilitates the construction of meanings, learning to use terms that convey mathematical relationships implies that young students are challenged in the complex process of mathematical interpretations. Therefore, neither the process, nor the language created to convey those particular meanings, should be underestimated, or labeled as informal during the early years of mathematics education.

These educators' avoidance of the mathematics register revealed the existence of a particular early years mathematical discourse, favoring what was perceived as familiar (everyday) words over formal terminology and the analyses showed how teachers consistently used these terms as valuable pedagogical tools. Familiar terms (such as "the same") became tools for thought [12] for students to make meaning of perceptual and mathematical relationships. The findings further indicated the presence of semantic patterns between perceptual terms and the mathematics register and a slight movement from everyday and protoquantitative terms to the use of the register. This was made explicit when the teachers discussed the mathematical idea of "the same" as a starting point to later teach the meaning of "the same as" and "equal." A mathematical language pattern also emerged in the analysis between terms such as "number and digit," "groups and sets," take away/borrow and subtract", as well as between the expressions "number sentence and equation". Overall, it appeared that the three educators were conscious of these grammatical patterns and considered them to be tools in their scaffolding approaches.

The analysis also shows that in grade one the teacher focused on explaining to her students how to *do* mathematics and that she also used the register in the form of nouns (i.e., "subtraction," addition", "combination" "facts" "equation" and "digits"). In contrast, the avoidance of nouns by the preschool and the kindergarten educators when they were teaching math was of interest. When they provided a rationale for avoiding the use of the register, these two educators mostly referred to the use of nouns (i.e., "subtraction," "equal," "sets," "addition"). The analysis shows that the preschool and the kindergarten teachers chose instead to use verbs or terms that denoted the action or the actions of doing math. Such was the case of terms like "take," "take away," "change," "share," "borrow," "to count," "counting," "add," "make," and "making." This language choice appeared to be strongly rooted in these educators' figured worlds of early mathematics teaching and learning and in their beliefs about the fundamental value of young children doing mathematics.

5. Conclusions

From a linguistic perspective, the ability to code-switch implies having a certain level of proficiency with the languages involved; however, switching to the mathematics register when teaching number sense activities to young students, was not a straightforward task. Overall, the study revealed how the three educators themselves encountered a crisscrossing of discourses [23] that merged the math register, the language that explains the math register, as well as their own interpretations, perceptions, values, and beliefs of the school mathematical discourse. Above all, the educators who participated in the study relied on their perceptions, figured worlds, and understandings about mathematics and language to make language choices and to decide what they thought was best for their students. With the exception of a few stanzas, the teachers agreed that their language choices had a purpose, thus revealing their pedagogical consideration of these matters. This certainly points out the critical importance of educators' meaning making processes, as well as the tremendous value of educators' thinking about the mathematics meanings carried by mathematics language. As we consider Vygotsky's ideas [12], we argue that educators' knowledge about the meanings carried by the language of mathematics could function as a tool for *pedagogical* thoughts. We also contend that by making both the language of instruction and the mathematics register the focus of educators' pedagogical attention, early mathematics instruction could strongly benefit.

The innovative approach taken in our study regarding code switching has revealed this construct as a powerful tool that could impact teachers' meaning making processes, concept teaching and the overall pedagogy of early years mathematics education.

Previous research strongly suggested that adults' math talk facilitates children's development of mathematical knowledge, and that the richness of the interactions between children and more experienced interlocutors (parents and educators) fosters children's mathematics learning and willingness to learn mathematics [33,34]. Hence, evidence-based mathematics research certainly highlights that early mathematics learning is critically impacted by the experiences young children have with mathematics and with the possibilities of early mathematics talk. Our study aims at moving these ideas forward and proposes that interrogating and researching math talk with a code-switching lens might help teachers and researchers to better understand when, how, and why adults use the mathematics register and/or the language of instruction to support young children's meaning making in mathematics.

Through the exploration of code switching, the study highlighted the rationale for educators' language choices; in particular, the study revealed an interesting insight for mathematics education when the three educators explained their decisions to "not switch" to the mathematics register, and instead used everyday, protoquantitative, and/or action terms. We found that in most scenarios, the educators' language choices were grounded in assuring both good communication flow, and allowing for mathematics meanings to be interpreted, by *not* switching to the mathematics register.

These educators' avoidance of the mathematics register revealed the existence of a particular early years mathematical discourse, favoring what was perceived as familiar (everyday) words over formal terminology and the analyses showed how teachers consistently used these terms as valuable pedagogical tools. Familiar terms (such as "the same") became tools for thought [12] for students to make meaning of perceptual and mathematical relationships. The findings further indicated the presence of semantic patterns between perceptual terms and the mathematics register. We contend that if the purpose of school's mathematics instruction is to help students to move along a continuum of learning the meanings of mathematics, then educators' awareness of the semantic patterns of language could become a crucial tool to scaffold students learning. Our argument is that thinking about semantic patterns and switches might help educators think about the intrinsic relationship between language and mathematical meanings. In addition, this would assist mathematics educators and researchers to further explore how teacher talk can best support young students to learn both vocabulary and mathematics. Further research is needed to investigate educators' code switching in all domains of early mathematics teaching. Examining the role of code switching in different early years settings (childcare facilities, preschools, kindergarten classrooms, elementary schools) is an innovative way in which to understand the talk that surrounds the mathematical experiences that occur while honoring the immersive nature in which young children come to learn to talk mathematics.

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