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Young children's appropriation of mathematical discourse: Learning subtraction in a plurilingual classroom

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I describe a teaching experience I carried out in Malta with a class of 5-year-old children of different language groups. The language of instruction was English and the topic subtraction. I explicitly taught mathematical expressions and sentence frames and planned class and paired activities wherein the children themselves would use the language to express the concepts at hand. The theoretical framework underlying my interpretation of the children's efforts is learning-as-participation. More specifically, I used Krummheuer's empirical model designed for interpreting classroom interaction in terms of producers and recipients. My teaching experience illustrates that with careful attention to both mathematics and language objectives, young learners in plurilingual Maltese classrooms can appropriate and use mathematics discourse within structured activities. However, more research is needed with regard to how students might use this language to author novel contributions.

Keywords: Learning-as-participation, mathematical discourse, subtraction, elementary education.

Introduction

Although the academic language for mathematics in Malta (an ex-British colony) is English and written texts are in English, interaction in classrooms is usually conducted through both Maltese and English. However, the number of non-Maltese students in classrooms is increasing over time, prompting teachers to use more English during lessons; although English may not be the non-Maltese children's home language, it is more likely that they would be familiar to some extent with English rather than Maltese. Anecdotal evidence suggests that teachers generally view this situation to be problematic, as they need to cater linguistically for Maltese and non-Maltese children. I carried out a study in the form of a teaching experience with a mixed language group of children with the aim of encouraging students to learn and use topic related language. My reasons for carrying out the study were (1) to apply to the Maltese context, the recommendation from the field of mathematics education for teaching mathematics language explicitly; (2) to focus on specific aspects of the mathematics register. I hoped that the reflections would aid me in my discussions with local colleagues, trainee-teachers and policy-makers on medium-of-instruction issues. My research question was: *How can children of different language groups be supported to learn English mathematical language?* By 'learning' I mean that the children would be able to express mathematical ideas through appropriate language during and after a series of lessons wherein specific language structures were emphasized.

Learning mathematical discourse

Several researchers, among them Gibbons (2015) and Murray (2004), make a strong case for teaching students explicitly how to talk about mathematics. Learning the language of mathematics allows individuals to express the ideas and concepts that form the discipline of mathematics, and by learning the language pupils begin to be enculturated into it (Lee, 2006). Thus, children learn the *discourse* of the discipline. This includes more than just learning subject specific vocabulary. Rather, it involves

learning - and using - the ‘ways of saying’ particular to the subject. For example, Sammons (2011) states that students need to learn how to formulate questions, make inferences and predictions; Murray (2004) and Gibbons (2015) recommend reflective journal writing as part of learning mathematics while Gerofsky (2004) considers word problems to be a genre forming part of the discourse. Whereas learning mathematical discourse is important for all learners, second-language learners have the dual task of learning the second language and content simultaneously (Bresser, Melanese & Sphar, 2009). Consequently, the teacher of second-language learners faces the challenge of not only making the mathematics lessons comprehensible for students, but also of ensuring that the students have the language needed to express their grasp of mathematics concepts. Coggins, Dravin, Coates and Carroll (2007) and Melanese, Chung and Forbes (2011) offer suggestions for classroom activities to support these students in learning ‘academic’ language, while Gibbons (2015) suggests that when planning lessons, both subject and language objectives should be listed.

In her consideration of mathematical language as a ‘register’, Morgan (1998) highlights grammatical features such as the imperative (command) and nominalization (nouns derived from verbs like *rotation* and *construction*), the passive voice (e.g., a line is drawn), being concise and the use of symbols. Whereas Morgan referred to written mathematics, these features also contribute to spoken mathematical discourse. Prediger and Wessel (2011) link the verbal register with what they call non-verbal registers including concrete, graphical and symbolic-numerical representations. They note that cognitive development of mathematical concepts is deeply connected to the ability to relate concepts in different representational modes. In this study, particular features of the register were addressed and developed by using them alongside non-verbal representations.

Theoretical framework

Lave and Wenger (1991) proposed that learning can be considered as participation in a community of practice. As students progress in their learning of an apprenticeship, they move from what Lave and Wenger call ‘peripheral’ to ‘full’ participation (p. 37), which involves learning the tools of the activity and gaining autonomy. Dealing with a similar theme of apprenticeship, Rogoff (1995) writes about two concepts: *guided participation* and *participatory appropriation*. The former refers to the mutual involvement of individuals, including communication, in a collective valued activity. ‘Participatory appropriation’ refers to the process by which individuals transform their understanding of, and responsibility for, activities through their own participation. In the context of the mathematics classroom, ‘learning’ may be taken to be the participation in the practice of the discourse of mathematics. Krummheuer (2011) has queried how the sensitizing notion (Blumer, 1954) of learning-as-participation can be described or represented on an empirical level and he proposes a framework for this purpose. He widens the dyad ‘speaker/listener’ to *multiple* roles so as to account for the multiple individuals normally participating in a group conversation such as that of a classroom context (ibid, pp. 84-85). For participants who are listening (recipients), he proposes the following roles; the first two refer to direct participation, while the latter two to indirect participation:

- Conversation partner (addressed by the speaker);
- Co-hearer (unaddressed by the speaker);
- Over-hearer (tolerated by the speaker);
- Eavesdropper (excluded by the speaker).

For participants who are speaking (producers), Krummheuer suggests these roles:

- Author (responsible for the content and the formulation of an utterance);
- Relayer (not responsible for either content or formulation; echoes the author);
- Ghostee (takes over the identical formulation and uses it to try to express an original idea);
- Spokesman (expresses the same idea with his or her own formulation).

As Krummheuer points out, this model has the advantage of accounting for the process of moving from ‘legitimate peripheral participation’ (as evidenced by the roles of eavesdropper, over-hearer, co-hearer and relayer) to ‘full participation’ (role of author), through the intermediate stages of spokesman and ghostee. Using this model, it is possible to interpret classroom interaction and participation, and hence learning, in a more specific way. Whereas Krummheuer (2011) used the model to interpret a small-group discussion, I apply it to a whole-class setting.

Research context and method

An ethnographic approach was considered suitable since I wished to describe the practices of an educational community. Since my focus was the details of a teaching/learning context, I considered the case study method to be appropriate (Yin, 2014). I approached a school where the Head of School was an acquaintance of mine, and she put me in touch with a Grade 1 teacher, whom I call Ms Jenny. Most of her children were 5 years old at the time of the study. The class comprised 22 children and exemplified a ‘superdiverse’ context (Barwell, 2016). There were nine children of whom both parents were Maltese; seven children had one parent Maltese and the other non-Maltese, namely Australian, Irish, Bulgarian, Serbian, South African, two Libyans. Five children’s parents came from varying countries: Italy, Greece, Hungary, Ecuador, South Africa. One boy had a Finnish father and a Kenyan mother. All the non-Maltese children understood English with different levels of confidence; I am not in a position to know their exact language experiences through which they learnt English, but from the conversations I had with some of the children it transpired that those who had one Maltese parent used English with this parent. Some of the non-Maltese children understood some Maltese and could say a few words. The Maltese children spoke Maltese fluently and understood English, but their speaking proficiency varied. Ms Jenny’s class situation prompted her to use English as the medium of instruction. Some of the Maltese children used Maltese when communicating on a social level. I did not hear any of the other languages during my time in the classroom, although I cannot exclude that the two Libyan children might have used Arabic to communicate outside the classroom. Ms Jenny and I agreed on the topic to be taught: Subtraction. 9 one-hour lessons were given and these were video-recorded. The focus of this paper is on the 5 lessons on subtraction as separation or ‘take away’. Parental and the child’s own consent was sought for children to show up on the cameras. If either withheld consent, the child was placed out of camera view. I interviewed some children individually before the lessons, asking them about the languages they spoke; I also confirmed that Subtraction was going to be new to them as a school ‘topic’. Three days after the lessons ended, I spoke to the children again, asking what they recalled. Children were chosen on the basis of consent obtained from both themselves and their parents; six were interviewed prior to the lessons, seven after. The interviews were audio-recorded.

I wished to present the children with mathematics/language and to see if, and how, they would appropriate the targeted discourse. The mathematical objectives of the lessons were: subtraction as

separation using pictures, blocks and fingers; symbolization ($5 - 2 = 3$) and translating story problems into subtraction operations. The related language objectives included the following structures: making statements using specialist vocabulary with regard to items (“Five [blocks] take away one is four”), using the imperative (“Take away two!”), asking a mathematical question (“How many left?”), ‘reading’ concisely symbolization ($5 - 1 = 4$ read as “five minus two equals three”), and formulating story problems orally (“Ms Jenny has 5 cookies. She eats 2 cookies. How many are left?”). Resources included a story book, pictures, blocks and fingers. As suggested by Bresser et al (2009), I modelled sentence frames during whole-class discussion, then set paired tasks during which the children were encouraged to use similar language. Some pairs (based on consent) were recorded using an audio-recorder. Individual worksheets were also set, of which photos were taken after the children completed them. In order to analyse the data, I studied the lesson, pair-work and interview recordings in detail, together with the completed worksheets. I focused especially on children’s contributions, now interpreting my original, general aim of getting children to use mathematical language in terms of Krummheuer’s framework.

Teaching and learning subtraction as separation

Classroom interaction is a complex activity, with participants’ roles interweaving. However, for the sake of presentation, I here tackle the roles separately. Names are pseudonyms. In the transcripts, the language is presented as stated by the children, and so in some cases may differ from standard English.

Teacher as author, children as recipients and relayers

In order to introduce the children to the new expressions, I first authored them myself within a whole-class discussion. In these situations, the children took the roles of either conversation partners or co-hearers, since I could not interact with all children simultaneously. In a typical ‘whole-class’ style of interaction, I sometimes drew on particular children (“This one’s for Andrea”) while at other times I selected children with raised hands, or allowed a chorus answer.

The following is an illustration of how I introduced an expression and encouraged the children to relay it back. The conversation follows Ms Jenny’s reading of the story ‘Monster Musical Chairs’ (Murphy & Nash, 2000) during which I had used statements such as “Three monsters take away one monster leaves two monsters”, while showing up large number cards.

- MTF: *(Referring to the monster pictures attached to the whiteboard).* I’m going to say something important: “Six take away one leaves five”. *(MTF simultaneously removes one card).* Now I need Dragan to say “five take away one leaves four”.
- Dragan: *(As MTF removes another card).* Five take away one leaves four.
(Serbian/ Maltese)
(...)
- David (Maltese) *(A short while later with reference to three attached monster cards).*
Take away ...
- MTF: *(Indicates the three cards attached to the whiteboard).* First say how many there are. *(Slowly)* Three – take – away – one – leaves – two.
- David: *(Saying it with me).* Three take away one leaves two.
- Children: *(Some children in the class say it with myself and David).*
- MTF: I want to hear you say it.
- Children (chorus): Three take away one leaves two.

For some children, relaying was not a trivial matter. For example, in the second lesson I introduced the question “How many left?” or “How many are left?” During this lesson, Lili (Hungarian) relayed this as “How many is?” but the following day I overheard her ask the question correctly to her task-partner. Initial difficulty may be due to the fact that English might not be a child’s first language. Age may also have an impact on how quickly a child might pick up a new expression; these young children were still developing general language communication skills. Once a key phrase was practised a number of times, I encouraged children to offer their own examples, thus giving them the opportunity to act as ghostee or spokesman.

Children as ghostees and spokesmen

Taking the role of ghostee (identical formulation, original idea) first occurred during class discussions. For example, in the second lesson I showed up picture cards, starting with six, decreasing to zero, each time asking a child to express what we had observed during the monster story. By this stage in the lesson, we were using both expressions *take away leaves* and *take away is*.

MTF: What shall I do with the picture?
 Kylie:(Australian/Maltese) Take away!
 MTF: So what shall I say?
 Kylie: Three take away one is two!

Although Kylie’s idea was not ‘original’ as such, I still consider that Kylie had progressed a step ahead of simply repeating after me, or with me. By Lesson 3, the children had picked up a lot of confidence, sometimes using the formulation to ‘jump the gun’. For example, in one activity I was asking children to show up a certain number of fingers, then take away (put down) a number of them. I had previously set two examples, guiding them with questions.

MTF: OK, another example. Seven fingers...
 Child 1 (unseen): Take away four!
 Sofia (Bulgarian/Maltese): It’s three!
 MTF: Listen carefully!
 Child 2 (unseen): Five! Five!
 Child 1 (unseen) No, four!
 Children (chorus): Seven take away four is/leaves three.

Another context in which the children took the ghostee role was during a structured paired activity. For example, in the excerpt below Sofia and Lennie were using monster pictures.

Sofia (Bulgarian / Maltese) (*Puts out six pictures, removes one*). Six take away one is five.
 Lennie (South African/Maltese) (*Removes a picture*). Take away /
 Sofia: (*Interrupts*). FIVE take away.
 Lennie: Five take away one is four.
 Sofia: (*Removes a picture*). Four take away one is three.
 Lennie: (*Removes a picture*). Three take away one is two.

It took some time for some children to get accustomed to stating the original number; as Lennie did, they might say “Take away two is three”. I drew their attention to stating the first number; this was important as a preparation for the standard symbolization $5 - 2 = 3$ that was introduced in Lesson 4.

It is not possible, nor necessary, to insist on identical formulations when working with mathematical discourse, since it would render the language-use artificial. Indeed, taking the role of spokesman (same idea, varying formulation) played a crucial part, since it allowed the children to express themselves freely and to draw on English *as they knew it* to express the mathematics at hand. This helped create an inclusive context, build up their confidence in English and mathematics, and allow me to gauge their understanding. For example, during a paired activity with blocks, the children were required to give an instruction to their partner (use of imperative, e.g. “Show six blocks”), then ask “How many (are) left?” Some children asked the question differently, for example: “How much is there?” (Sofia, Bulgarian), “How much is there now?” (Andrea, Ecuadorian), “How many blocks there left?” (Shania, Maltese) and “How many is the answer?” (Ritienne, Maltese). During the paired activities, Ms Jenny and I had monitored the children’s work, using the new expressions as we interacted with them and, through questioning, encouraged them to use the expressions themselves. Plenary sessions in which we reviewed a lesson also allowed the children to express themselves as they wished, while using the new expressions.

- MTF: What was that special word we were using today?
 Ian (Maltese): We were taking away.
 MTF: Can somebody remember what we were doing when we were playing teacher?
 Sven (Finnish/Kenyan) We was ... we was ... we was asking to show ... to show ... to show ten blocks.
 MTF: Good! We were asking our friend to show blocks. And then, Sven, what did we ask them to do?
 Sven: To ... to ... to ... to take away.
 MTF: And then what did we ask our friend? ... Luca?
 Luca (Italian): How many there left?
 MTF: Very good! How many are left?

A number of the children had another opportunity to take the role of ghostee or spokesman during informal individual interviews I carried out with them. In this context, I asked open questions like “Tell me what you remember”, prompting them to use the language – or similar - that we had focused on in the lessons. Following are two examples. In relation to word problems, Dragan used the story problem formulation to offer an example about himself, while Mohammed articulated a story sum with varying formulation, drawing on his knowledge of English as best he could.

- Dragan Dragan has five cookies and he ate three, and it’s two.
 MTF: Do you remember that question we were asking?
 Dragan: Yes. ‘How much are left?’

Mohammed: Ms Farrugia is, have a ... like ... eleven biscuits and he eats ... em ... six biscuits.

Children as authors

The role of ‘author’ is one that implies original input by the speaker and hence the role implies a certain autonomy. In the lessons on subtraction as ‘take away’ I did not recognize instances when children acted as authors in the sense of them coming up with novel input that could shape the

discussion, or influence other children's learning of subtraction. I believe that the reason for this was the structured nature of the activities. Due to my intention to stress and develop specific mathematical language, the whole class conversations were shaped by myself. Furthermore, the paired activities had particular instructions to follow. Although children offered their own subtraction examples on the worksheets, including drawings of their choice, I would still say that they were following quite closely the structures I had taught them. Of course, the children did digress in their talk during the pair work and as they worked out the written examples on the sheet. However, this alternative talk tended to be social talk, such as "Look, my monster is green" or "Hey! Don't take our blocks" and so on, as one might expect from children this age.

Conclusion

From a researcher perspective, my study served the purpose of supporting international research that highlights the benefits of giving explicit attention to academic/English language with non-English speakers. It provides an example of focusing on specific features of the register. My study also illustrates an attempt at addressing mathematical language in a plurilingual classroom, and an application of Krummheuer's (2011) framework. From a teacher perspective, I concluded that the strategies I had planned had been effective in reaching my aim which was to enable the children to use features of mathematics discourse, namely specialist vocabulary, the imperative, asking questions, interpreting symbolization and the story problem genre. Thus I went some way in guiding a group of children with very different language backgrounds and differing proficiency levels of English to appropriate the 'academic' mathematical discourse and hence to increased participation in the discipline (Lave & Wenger, 1991). However, according to Krummheuer (2011), *full* participation in the practice is achieved through authorship. Due to the structured nature of the class activities, I cannot say that the children fulfilled the role of authors; it is likely that open-ended style activities are required to allow for authorship opportunities.

In conclusion, I note that on one hand the explicit attention to language can help to set up a reciprocity of conversational English and mathematical discourse, with potential benefit for both aspects. This would seem to be an important teaching strategy for mixed-language groups. On the other hand, the attention to language in itself can be restricting unless further opportunities are provided for more open-ended tasks. In the latter tasks, one might hope that the language expressions learnt during structured activities might then be utilized as students offer novel ideas. This would result in students' authoring by using the mathematics register - surely the 'fullest' verbal participation that one can expect from mathematics learners. Of course, appropriating mathematical discourse is not something that can be achieved over a few lessons, especially in the case of very young children learning mathematics in a second or foreign language. The next stage in my line of research is to explore how newly learnt language structures can be encouraged in a plurilingual classroom to author original contributions to the development of the mathematics at hand.

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