EMBODIMENT IN TEACHING AND LEARNING EARLY COUNTING: GROUNDING METAPHORS

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This paper contributes to the theory and evidence that mathematical cognition is embodied. Drawing on the practices of primary teachers in South Africa engaged in a longitudinal research and development project – Wits Maths Connect–Primary – we report on aspects of lessons aimed at developing number sense through whole-class teacher-learner interaction. Two episodes are analysed from an embodied cognition perspective. The episodes focus on helping Grade 1 (6-year-olds) learners become fluent in counting forward and back or ordering numbers. Analysis reveals different embodied metaphors underlie the teachers' actions, the nature of which are likely to lead to different learning opportunities. We conclude that our analysis supports a theory of embodied cognition, and demonstrates its usefulness as an analytical tool.

INTRODUCTION

Authors are increasingly arguing that cognitive understandings in general and mathematics in particular are embodied – rooted in perceptual and physical interactions between the body and the world (Barsalou, 2008, Alibali & Nathan, 2012). In this paper we examine two assertions that flow from this theoretical position. First, that teachers, as mathematical knowers, will themselves have embodied understandings and will, often intuitively, draw on these in their teaching. Second, that any such use of embodied metaphors must take the learners' embodiments into consideration if the metaphors are to be supportive of learning.

RESEARCH CONTEXT

National standardized and international comparative test results consistently present a bleak view of mathematical performance in South Africa. For example, the 2012 Annual National Assessments (ANAs) results indicate 27% as the national mean mark at Grade 6 (predominantly 11- to 12-year-olds) (Department of Basic Education (DoBE), 2013-a), down three percentage points from 2011 and well below the target of 60%. In this context, a longitudinal research and development project – Wits Maths Connect–Primary (WMC–P) – is developing and investigating interventions to improve the teaching and learning of mathematics in ten government primary schools. One particular intervention is the Lesson Starters Project (LSP) focusing on improving number teaching in the Foundation Phase so that the students' develop better number sense.

The focus of the LSP is linked to the national South African Curriculum and Assessment Policy Statement (Department of Basic Education, 2011) and the district

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Gauteng Primary Language and Mathematics Strategy (http://gplms.co.za/) that together prescribe content, sequencing and teaching timeframes. Our partner schools are under pressure to follow these policy drivers so we are focusing on the policy mandated 'mental mathematics' within 'whole class activity' lesson sections.

The CAPS documents provide brief guidance on approaches and tasks expected to figure within this mental mathematics teaching, for example:

> Mental mathematics will include brisk mental starters such as "the number after/before 8 is; 2 more/less than 8 is; 4+2; 5+2, 6+2" etc. (DBE, 2011, p. 11)

Despite such exemplification a diagnostic report on Grade 3 learners' performance on the 2012 ANAs identified mental skills as a particular weakness that included poor understanding of 'number concept as demonstrated in being able to count forwards and backwards' (DBE, 2013-b, p. 6).

Collecting baseline data in 2011, the project team observed and videotaped a numeracy lesson from each of the Grade 2 classes in the ten project schools, to gain insights about the nature of teaching and learning, and the classroom contexts. Analysing this data revealed teachers' random selection and sequencing of tasks led to a lack of coherence in and across tasks, and in task enactment. The resulting weak coherence within teaching exhibited 'extreme localization' and 'ahistoricity' (Venkat & Naidoo 2012). Such practices, it is argued, severely impair possibilities for learners to understand number as a connected network of ideas.

Two years later, video data from Grade 1 classes (in the same ten schools) show improvements in coherence and pacing, so our analysis is now examining nuances in how teachers bring coherence to the lesson starters. In doing so, we find embodied cognition a helpful theoretical tool.

THEORETICAL BACKGROUND

As yet there is no unified theory of embodied cognition. Wilson (2002) suggests that there are at least six different views of embodied cognition, one of which is that 'off-line' cognition is body based – this is broadly the view taken here. Dehaene (1999) argues that there are spatial aspects to developing number understanding, such as the representation of integers spaced along a line, while Lakoff and Núñez (2000) argue for an embodied view of mathematical understanding, suggesting that developing understanding that goes beyond subitizing small quantities draws on learners' metaphorising capacities – making sense of numbers (as concepts) through various bodily experiences, such as associating number with distance, movement and location, as well through handling collections of objects.

Such metaphorising capacity is linked, Lakoff and Núñez argue, to two types of metaphors: grounding and linking. 'Basic' grounding metaphors 'allow you to project from everyday experiences (like putting things into piles) onto abstract concepts (like addition)' (p. 53) while linking metaphors lead to 'sophisticated' or 'abstract' ideas and, in contrast to grounding metaphors 'require a significant amount of explicit instruction' (p. 53). Other theorists support this notion of *grounding* as setting up a mapping between the familiar and concrete and the abstract (Nathan, 2008).

Our videos of the more recent lessons reveal teachers intuitively making use of embodied metaphors. Below we analyse two instances to explore how such metaphors play out in practice and whether this likely to help learners better understand number.

DATA SOURCES

Our data are drawn from the 2013 videotaped classroom lessons of Grade 1 teachers who had also been filmed teaching Grade 2 in 2011 (n = 7). The two lessons focused on here represent the broader dataset in having extended instances of whole class talk around typical tasks. But they also provide 'telling cases' (Sheridan, Street, & Bloome 2000) as both teachers drew on different bodily metaphors.

The first teacher, M is an experienced teacher in a disadvantaged school, whose medium of instruction is Tsonga. The second teacher, R is another experienced teacher at the same school but whose medium of instruction is Tshivenda.

DATA ANALYSIS

Analysis comprised 4 phases: (a) creating a transcript, (b) fleshing out the evidence (c) interpreting (d) producing a 'thick description' and analysis of selected episodes.

Creating a transcript

Bilingual speakers transcribed the video recording, following instruction to capture all the teacher's talk within the lesson and any objects/representations referred to.

Fleshing out the evidence

A narrative account of the unfolding of the lesson was created, using the video to include detail not captured in the transcribing. This account was then parsed into episodes, usually identified by the introduction of a new task, but sometimes marked by shifts of attention within tasks. To improve accuracy and detail, the project team viewed the video recordings several times to clarify the interaction between the enactment of the episode (teacher talk and actions and pupil responses), the choice and sequencing of examples, and the use artifacts to support the teaching.

Interpreting

The team examined and discussed each episode to reach consensus on the likely (a) teaching intentions, and (b) learning opportunities. These interpretations were warranted through reference to the data with the teaching intentions imputed through the enactment of the episode, and not necessarily as explicitly articulated by the teacher. Similarly we interpreted learning opportunities through how the episode played out and the likely consequences for learning.

Producing a 'thick description' and analysis of selected episodes

Many of the episodes identified were, empirically and theoretically, of limited interest as they focused on learners practicing what they already knew. Lessons were then examined for 'critical incidents' – particular episodes where it was clear that learners were not already confident in content being addressed. The team discussed, analysed and wrote up these incidents. We report on two such critical incidents here.

LESSON STARTER CRITICAL INCIDENTS

Incident 1: Teacher M – Forward and backward counting between 1 and 20

This episode was towards the beginning of the starter activity. The teacher settled the learners down and then asked them to count forward from 1 to 20 as a whole class. Some learners were seen using their fingers putting out 1, 2, 3, … while counting. M asked learners to count backwards from 20 to 1. Several learners were heard to say 'twenty, ninety, eighty, seventy,...' and many learners were observed not saying anything. The teacher stopped the class count, saying, 'when counting backward you should say twenty, nineteen, eighteen as you are reversing'. She demonstrated this by taking three steps backwards and gesturing in the direction of her movement by pointing both thumbs back over her shoulders.

> M: If we are counting forward we say one two three up to twenty. In the backward counting we say twenty, nineteen, eighteen. Now let's count backwards again.

Learners started counting: again many could be heard saying 'twenty, ninety, eighty, seventy'. M stopped the counting and shook her head.

> M: We are counting within the range of twenty. You should say, twenty, nineteen not ninety.

M moved from the front of the class to take up position at the back of the room. Stepping towards the front, M counted her steps 'one, two, three, ...' At twenty she stopped counting and stepping, and pointed forward (to the front the class, the direction she had been walking in) with both hands. She then made a backward gesture by pointing her thumbs over her shoulders, saying, 'We are reversing, reversing'. Without turning round, M retraced her steps from the front of the class to the rear, simultaneously counting backwards from twenty to one. As she did this she emphatically enunciated 'nineteen, eighteen' and so on. M asked learners to again count forward from one to twenty. She coordinated this with pointing on her fingers 'one' (thumb), two (forefinger) and so forth as everyone counted, clapping on 'ten' and 'twenty'. Learners were seen to follow the teacher and use their fingers similarly. M asked learners to count backward from 20 to 1. Most learners were observed to count correctly: twenty, nineteen, eighteen down to one.

> M: That is good. So next time don't say ninety. It's nineteen, eighteen.

Analysis

The task enactment showed that learners were fluent in the forward counting sequence but struggled with the backward number word sequence, confusing, for example, ninety with nineteen. M stopping the backward counting and commenting on the errors reveals her awareness of this difficulty. Her actions of stepping forward and backward, language of 'reversal' and gestures of forwards and backwards coheres with the task and teaching intent.

Establishing a sense of numbers as points on line draws on what Lakoff and Núñez (op. cit.) refer to as the 'source-path-goal' schema based in metaphors of a moving trajectory, from a source to a goal. This schema has an internal spatial logic with implications such as having followed a trajectory to a goal, then all prior places on that trajectory must have been passed through. Learning to count backwards could therefore be metaphorically linked to retracing one's path along the trajectory, revisiting all the previous locations in reverse order.

M's actions explicitly embody this metaphor of a moving trajectory. By physically moving to the back of the room, her stepping forward and back and accompanying gestures all were coordinated with the perspectives of the learners: forward in the direction to which the learners faced, backwards being in the same direction over everyone's shoulders. Stepping forward M physically laid out a trajectory, orally indexing locations along her path through counting her steps out loud. Arriving at, and still facing the front of the room, she gestured to indicate the forward direction of the trajectory and then the reverse of this by pointing back over her shoulders and stressing 'we are reversing'. The use of 'we' can be taken as an invitation to the learners to imagine themselves moving, even though only the teacher was actually moving. Without turning round, she retraced her steps, orally indexing these with the backward counting sequence. Thus M clearly enacted a 'source-path-goal' and reverse trajectory metaphor in ways that fitted with the learner's embodied positions and how they would experience the trajectory were they to travel it themselves. Although Lakoff and Núñez take the trajectory metaphor to be a linking metaphor, the teacher's treatment here suggests to us that it can be used as a grounding metaphor as it is set up and used with little explicit explanation and learners appeared to relate to it.

There is also evidence of M's awareness that the counting back errors might arise from the difficulty in hearing the distinction between 'nineteen' and 'ninety' and confusion with the other counting sequence of 'ninety, eighty, seventy, ...' that is frequently practiced. Here again, the teacher addressed this in an embodied way through over-emphasising the enunciation of the counting words. While elsewhere in our data we have found teachers using enunciation to address isolated difficulties, the teacher here incorporates her handling of enunciating words within a coherent and connected moving trajectory metaphor that emphasizes a traversing back through the same path that has just been travelled in the forward direction. Thus 'ninety' is not just an error of enunciation; it is treated as a spatial error in that this indexing of position did not feature in the forward direction.

Incident 2: Teacher R – Numbers 'behind' or 'in front of' in the range 1 to 10

Up to this point in the lesson R had taken the class through counting forward and backwards to ten and combining two numbers with a sum less than ten (using fingers as artifacts). R turned to a partially completed number line on the chalkboard (0, 4 and 6 labelled, ending at an unmarked 8) to work on finding the missing numbers.

R walked towards the board, which had taped to it a column of numeral flashcards from 0 to 10. Taking down the numeral '5' R asked 'what number comes behind this number?' She spoke facing the class and simultaneously gestured by raising her right hand and pointing over her right shoulder towards the board. Some learners said 'four', others 'six'. R restated 'which number comes behind this number?' More learners were heard to state 'four'.

R: Isn't the number four coming in front?

Now most learners said 'six'. R took down the numeral '8' flashcard and asked 'which number comes behind this one?' As she spoke she again accompanied this with her gesture of raising her hand towards and over her right shoulder. Some learners said 'nine', others 'seven'.

R: Seven? Is this not a number that comes in front?

Learners said 'nine'. R took numeral 3 down.

R: What number comes in front of this one?

Learners: 'Three', 'two', 'four'

R: Four? That is the number that comes behind.

Immediately some learners called out 'two'. R responded with 'that is the number that comes in front'. However, at the same time, other learners were still heard to say 'four'. The teacher did not respond and moved on to the next task.

Analysis

Within a moving trajectory metaphor, four could be considered to be behind five in the sense that having travelled past point four to point five, the former is left behind. The language of behind can also suggest a metaphor of following not leading – if numbers (represented here by numerals on flashcards) are likened to being 'strung out' along a line, then the numbers closer to the starting point are, in a sense, behind those coming later: such a metaphor could account for learners giving (from the teacher's perspective) incorrect answers.

To describe four as 'coming in front' of five suggests a different embodiment – perhaps a staircase metaphor of 'steps' going up from one to ten, in order of height, the lowest step to the front (such a model can be created using one to ten number rods, although we have not seen it used by our teachers). The teacher's talk and gestures suggests a positioning within the metaphor, like an ordered set of Russian nesting dolls – shortest in front and others lined up behind in height order. Four would thus be in front of five. If she (the teacher) were 'occupying' the position in height order, of, say, five, then six would be behind her, consistent with gesturing over her shoulder.

Whatever the case, the metaphor here has a more 'static' aspect than in the other episode – R's gesturing indexes a stationery positional metaphor rather than a momentary position on a trajectory. In contrast to the way that teacher M took up position in the room so that her perspective corresponded to that of the learners, R's orientation was such that what was 'in front' or 'behind' *her* occupied a different space relative to that of the learners.

R's response to learners' incorrect answers was to use a rhetorical question to point out that they were wrong (from her frame of reference) – 'Isn't the number 4 coming in front?' While some learners then produce the 'correct' response, any learning provoked is likely to based in association – 'behind' associated with producing the next number name in the counting sequence, rather that being explicitly connected to some grounding metaphor.

DISCUSSION

We make no suggestion here that either teacher was working deliberately with any metaphors, but in keeping with Lakoff and Nunes' theoretical position, the internal consistency of language, gestures and positions strongly suggests a metaphorical origin to their cognition.

Teacher M unambiguously modelled a moving trajectory, embodying a metaphor of numbers along a path and her actions, gestures and talk are coherent and consistent, together with alignment between her spatial perspective and that of the learners. Doing so maximised the chances of learners engaging in '*simulated action*' whereby witnessing actions and imaging actually doing the actions activates appropriate brain areas (Alibali & Nathan, 2012, original emphasis).

In teacher R's case the consistent treatment of 'coming in front' or 'behind' across the examples suggests a different metaphor. Putting things in order of height is a possible grounding metaphor here in that the actions of such ordering (without measuring) require little direct instruction. However, both the more implicit nature of this metaphor in R's episode and the lack of coordination between her position and that of the learners makes it likely that the learners would find difficultly in engaging with this as a grounding metaphor.

CONCLUSION

We commenced with two assertions. First, that teachers, as mathematical knowers, will themselves have an embodied understanding and thus will, intuitively, draw on this in their teaching. In both cases here we are argue that the teachers' talk and actions exhibit evidence of being grounded in bodily metaphors, lending support, albeit limited, for the claims to mathematical cognition being embodied.

Second was the assertion that for embodied metaphors to be helpful, working with them must take the learners' embodiments into consideration. We see here one teacher successfully doing this and another acting more directly from only her position and perspective and thus limiting the potential grounding for the learners.

The theoretical position of teaching and learning number as grounded in embodied metaphors is validated by such examples and, moreover, provides a useful framework for analysis. Given the increased coherence and consistency that we are seeing in lessons, this inferring of metaphors provides us with a useful next step in working with teachers to elaborate, broaden and extend metaphors within their pedagogic repertoire for teaching number sense.

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