The role of gestures in supporting mathematical communication for students with language delays

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Despite the fact that discourse is an important facet of mathematical learning, most research on students with language delays learning mathematics has focused on their procedural fluency, with limited focus on their communication of mathematical reasoning. This study focused on two first grade students with language delays as they engaged in choral counting, an instructional activity designed to encourage mathematical discourse. Qualitative analysis of the techniques they used to express their mathematical ideas found that the students' use of gestures in relation to an artefact supported their mathematical communication.

Keywords: Mathematics instruction, language impairments, nonverbal communication, discourse analysis, pattern identification.

Introduction

Discourse mediates mathematical learning (Forman, 2003) by providing a conduit for students to participate in mathematical practices, particularly when discourse is defined as comprising all forms of communication—including language, gestures, symbols, and artefacts (Lerman, 2001). The importance of discourse to mathematics education is shown by its prominence in educational policy documents (see e.g. NCTM, 2000), which state that mathematics instruction focused on discourse should enable students to express their mathematical ideas, analyse the mathematical thinking of others, and clarify and consolidate their own understanding of mathematics.

Gersten et al. (2009) found that the process of encouraging students with learning disabilities to verbalize their thoughts is effective, and yet it is uncommon to see teachers encouraging mathematical verbalizations from students with disabilities. This is because the dominant instructional paradigm for teaching students with disabilities is teacher-led algorithmic instruction (Jackson & Neel, 2006), which is characterized by the teacher demonstrating a step-by-step procedure for completing a specific type of problem, and the students then using these same procedures to solve similar types of problems. This type of instruction leaves little space for independent student verbalizations. In this paper I explore what students with language delays learn about communicating mathematical ideas by engaging in an instructional activity—choral counting—that encourages students to engage in mathematical discourse.

In this study I use the term language delays to mean that the students had persistent difficulties with expressive and/or receptive language that interfered with their academic competence and had been present since early childhood, but was unrelated to low cognitive ability, hearing loss, autism, or other known causes.

Conceptual framework

This study is influenced by a sociocultural framework in which learning is defined as the transformation of participation in a cultural practice (Rogoff, 2003). The cultural practice examined in this study is discourse about mathematical ideas. Amongst the community of mathematicians, discourse between mathematicians about axioms and conjectures is an important cultural practice that allows them to refine and improve knowledge; this is different than the one-directional discourse that commonly occurs in school mathematics classes, with the teacher imparting knowledge to the students (Lampert, 1990). This study examines the transformation of practice as the students move from the type of discourse typical in school mathematics towards disciplinary discourse as they learn several practices that mathematicians engage in when discussing mathematics: making assertions and presenting evidence (Lampert, 1990).

Several researchers have used a sociocultural framework to understand how students with English as an Additional Language (EAL) participate in mathematical discourse (Turner, Dominguez, Maldonado, & Empson, 2013). It is often assumed that students with EAL will struggle to participate in mathematical discussions, but Turner, Dominguez, Maldonado, and Empson (2013) found that these students increased their participation when the teacher invited their participation, validated their participation by responding positively to their contributions and accepted a variety of resources as valid forms of communication including gestures, objects, artefacts, and the students' home language.

These findings about how students with EAL can be encouraged to participate more in mathematical discussions, may help us support students with language delays to participate more in mathematical discussions. At present students with language delays are assumed to fare better in environments that limit peer interactions (Griffin, League, Griffin, & Bae, 2013), however, since "content learning is inseparably bound up with language learning and vice versa" (Barwell, 2005, p. 207), students with language delays may actually need more opportunities to participate in mathematics discussions than typically developing students. They may need more practice communicating mathematically, just as they need more practice communicating in other modes. This means that mathematics lessons should be designed to support students' language goals as well as their mathematical content goals. These language goals will be more readily addressed with mathematical discussions than by direct instruction.

Significance of research

The research question explored in this paper is: What do primary students with language delays learn about communicating mathematically as they interact during choral counting? This study contributes to the field of mathematics education by helping researchers and practitioners understand more about the intersections of language performance and mathematics learning by examining a group of students who are rarely asked to communicate their mathematical ideas as they learn mathematical content.

Methods

Self-study

This study is an example of self-study action research, as I was both the Special Educational Needs (SEN) teacher for the participants and the researcher in this study. I used the position of the teacher to investigate an issue, try a new method, and examine it systematically (Ball, 2000).

This type of research has several advantages and disadvantages in regards to validity. My established relationship with the students meant that I knew the history of shared understandings within the class and understood the children's use of language (Ball, 2000), and could use this knowledge to understand to what the children were referring, thus increasing the validity of the results. On the other hand, as their teacher I had a vested interest in seeing the students learn, which is a threat to the validity of the results. As an attempt to offset this threat to validity I triangulated the data with several other sources of data. The reliability of this study would have been increased if I was able to include a report of inter-rater reliability for the results.

This study was motivated by my own experiences teaching mathematics as an SEN teacher. I had tried to teach mathematics through direct instruction for several years and was dissatisfied with the limited progress that my students were making in mathematics. Therefore I decided to try a new instructional activity that emphasized mathematical discourse—choral counting—and to examine this new activity systematically to discover whether it is a fruitful way to work with young students with language delays.

Participants

The participants in this study were two first grade (6-7-year-old) boys who received small group SEN services in the areas of mathematics, literacy, and communication in an urban area of the U.S.A.

Martin[1] and Ali were both members of my primary special education mathematics class (PSEM). They had both qualified for SEN services under the category of Developmental Delays. Although the category given to them by the school district was Developmental Delays, which suggests global delays, the term Language Delays more accurately reflects their difficulties. These students showed delays in their language development, but no delays in their self-help or motor skills, and only minor delays in their social skills. Therefore, I use the label Language Delays to refer to these students' disabilities.

Martin and Ali were selected because at the beginning of the study they both had Individual Education Plan (IEP) goals related to counting, were in first grade, had language delays, and remained in my mathematics class throughout the duration of the study. There were four other students in their mathematics group, but these students did not receive SEN services in my class through the entire duration of the study.

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[1] All names are pseudonyms.

Procedures

I chose to study the instructional activity of choral counting (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010) because it is an activity that incorporates both appropriate mathematical content for students in first grade and an opportunity for the students to engage in mathematical discussions. There are two sections to the choral counting activity: 1) rote counting, and 2) pattern identification and expansion. It is during the second section of the activity that students engage in mathematical discourse by expressing their own mathematical ideas.

In choral counting the teacher has to first choose an appropriate counting sequence for the students. For these students the counting sequences were by ones, twos, fives, tens, or backwards by ones. When counting by ones, the count started from a number in the low double digits because the students were very familiar with counting by ones from one. These counting sequences were selected because they were identified as the essential counting sequences for first grade students in the Washington k-12 Mathematics Standards (Office of Superintendent of Public Instruction, 2008), which were the relevant state standards in the time and place where this study was situated. Once the teacher has introduced the counting sequence to the students, the class counts together while the teacher strategically records the count on the board so that certain patterns emerged.

After writing three or more rows or columns the teacher stops the count and asks the students to identify patterns in the numbers. Once a student has stated a pattern they can be asked to extend, compare, or justify their pattern, and other students can be asked to build on what the first student has said.

The students in the PSEM class engaged in choral counting approximately weekly from November until March. They then continued to participate in choral counts once or twice a month from April until June. This resulted in eleven choral counting lessons over the year, each of which took approximately 20 minutes to enact. I additionally recorded my lesson plans, my reflections of each lesson, and asked the students to complete independent counts. Although I do not report my analysis of these additional sources of data in this paper, they did triangulate the data from the videos.

Data analysis

The data collected and analysed for this article consisted of two episodes from the videotaped choral counting lessons. The data were collected during a single school year, and were analysed systematically by drawing upon both sociocultural theory (Rogoff, 2003) and interaction analysis methodologies (Schegloff, 1997). In the initial analysis of the data, I used open coding to produce concepts, which were revised with further analysis. The resulting claims and assertions are based in the data and are therefore empirically grounded.

Results

In this paper I show how the students incorporated gestures towards the artefact into their interactions, and why this increased their communication of mathematical ideas.

In the first couple of choral counting lessons all of the students responded to the quest for patterns purely verbally. When asked what patterns he saw, Martin responded, “A square right there…Ooh! A triangle…Circle…Rectangle.” These verbal responses did not communicate enough information to help his classmates or teacher understand why he was responding with shape names, and the conversation about shapes petered out.

On his next turn Martin initiated a new form of communication about the numbers. Instead of remaining in his seat, he came up to the board and gestured towards the numbers he was referring to (see Figure 1):

Martin: I see zeroes

Teacher: Where. Tell me where. [Martin got up.] Tell me

Martin: Right here. [Martin went to the board and pointed to the zeroes in the final column. As he counted he pointed to each zero.] Ten. Twenty. Thirty. Forty. Fifty.

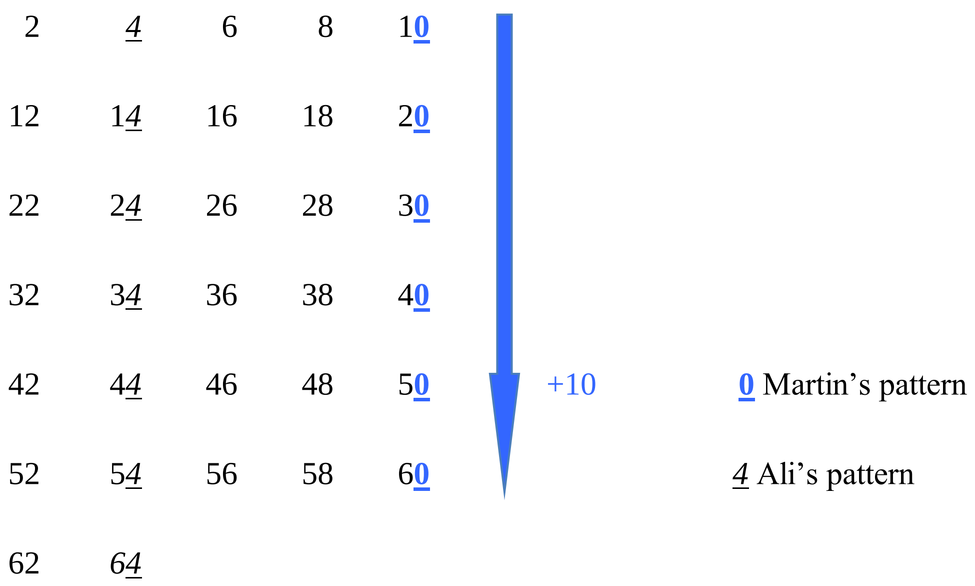

Figure 1: Count by 2s, December

In this interaction Martin defied the teacher’s expectations that he would respond to the question purely verbally. Instead he adopted some of the teacher’s communication style from the previous interaction with Ali by using the artefact to gesture towards the relevant numbers, but also innovated to convey more information. While the teacher had used a gesture that simply indicated the digits under discussion, Martin used a cohesive gesture that united two separate but related aspects of his idea (McNeill, 1992). Martin used pointing to indicate the repetition of the written zeroes in the ones place, while verbally reading the count by tens; in this episode Martin used a cohesive gesture to express his emerging understanding of the links between the symbolic and verbal representations of number. This corresponds to Garber, Alibali, and Goldin-Meadow’s (1998) finding that children often use gesture to express emergent learning.

Martin's initial comment about "zeroes" was clarified and expanded by his use of gesture. This expansion allowed the teacher to respond to his statement and prompt him to further expand on his idea.

Teacher: What are they counting on by?

Martin: Tens. [Confident voice.]

Teacher: Yeah. Tens. [Writes +10 beside the zeroes with an arrow pointing down.] That's a great answer.

The positive response that Martin achieved through this interaction encouraged other students to take up his innovation and by episode 4 it had become a norm for the students to come to the board when they were trying to communicate which numbers they were discussing. For example, in episode 4 Ali communicated that he saw a similarity between the numbers in the first row (see Figure 2) by both verbalizing the numbers he was discussing and pointing to the relevant numbers. The words that he said, "Tens…got a number one zero, one one zero," could have been easily misconstrued but because he came up to the board and pointed at the relevant numbers, his listeners understood exactly which tens he was talking about.

10	1**10**	2**10**	3**10**	**410**
20	120	220	320	
30	130	230	330	
40	140	240	34*0*	
50	150	250		
60	160	260		
70	170	270		
80	180	280		
90	190	290		
100	200	300		**10** Ali's pattern

Figure 2: Count by 10s, January

The use of gestures allowed Ali to clearly communicate his idea and the mutual understanding engendered by this exchange of ideas allowed his teacher to extend the conversation (Goldin-Meadow, 2003).

Teacher: What number will be here? [Teacher points to the right of 310.]

Ali: Four

Teacher: Four hundred [Writes 4.]

Ali: Ten. [Teacher writes 10.]

In this exchange Ali went beyond the initial statement of the pattern to extend his pattern to the next column while incorporating an unstated arithmetic sequence in the hundreds.

Discussion

This action research project improved the participating students' educational outcomes, challenged assumptions and provides a basis for a call to social action, which are all important goals for action research (Kincheloe, 2003; Somekh & Zeichner, 2009).

The instructional activity of choral counting improved the students' educational outcomes (Kincheloe, 2003) by transforming their participation in the cultural practice of mathematics discourse by challenging the assumption that students with language-delays will not be active participants in discussions around mathematics because they find the language too difficult (Fazio, 1999). Although both boys found it difficult to express their ideas verbally, they were actively engaged in the mathematical discussions and used gestures to enhance their communication. Thal, Tobias, and Morrison (1991) found that students with specific language impairments are often worse at gesturing than their peers, but that those whose gestures develop normally will later catch up with their peers in verbal speech. Therefore it is important to encourage the use of gestures among students with language delays and this study showed that allowing students with language delays to gesture and physically interact with the numbers can support their participation in mathematical discussions. My call to action is to encourage other teachers to involve their students with language delays in mathematical discussions and to encourage them to use gestures and artefacts to express meaning.

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