

WHAT'S IN A TEXT: ENGAGING MATHEMATICS TEACHERS IN THE STUDY OF WHOLE-CLASS CONVERSATIONS

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This paper discusses an activity done in a lesson study group of beginning teachers working in high needs urban schools. The activity involved the interpretative analysis of a whole-class conversation transcript, via functional grammar tools, with focus on how the teacher conducted the interaction. As a spoken text genre, whole-class interaction poses heavy demands on teachers in terms of their ability to provide skilful conduction. After presenting the text, we describe how it was read in our study group. This description is intended to show how the guided deconstruction of whole-class interaction texts can serve to strengthen teachers' awareness of the semiotic choices they have available for shaping the joint making of such texts and the effects of these choices in supporting students' mathematical meaning-making.

INTRODUCTION

This paper discusses an activity done in a lesson study group for beginning teachers. Participants in this study group are working in high needs urban middle schools, teaching mathematics to low socio-economic status 6-8 grade students from a wide range of cultural/ethnic/linguistic backgrounds as well as levels of academic performance. The lesson study group is part of a 3-year exploratory project (NSF, DRL 0822223) wherein mathematics teaching, learning, and learning to teach are addressed from a social semiotics perspective. This project involves two sub-groups of 6 teachers, each facilitated by a PI, which meet every other week for 3-hour sessions. The focus of the in-service activity is the "Necklace Text," a whole-group conversation excerpt captured in a 6th grade class taught by an experienced teacher.

For the analysis of classroom texts we draw upon systemic functional linguistics (SFL) (Halliday, 1994) and critical discourse analysis (Fairclough, 2003). Among the tools we borrow from SFL are: language as meaning potential; context, text, register, and genre; meaning as choice; teaching as enlarging students' meaning potential; the interpersonal, ideational, and textual meta-functions of language; grammatical form, speech function, and modality; material, mental/verbal, and relational meanings; and the packing of mathematical meanings into technical wordings via nominalization and grammatical metaphor. Rather than presenting these tools to participants as a crash course in functional grammar, we introduce them as we see them fit, during our lesson study activities of analyzing classroom-generated texts and artefacts, solving of non-routine mathematics problems, and planning, discussing, and revising lessons and lesson sequences.

SFL has proven well-suited for studying science and mathematics classroom texts (Atweh, Bleicher, & Cooper, 1998; de Freitas & Zolkower, 2009; Lemke, 1990; Morgan, 1998; Shreyar et al., 2009; Veel, 1999; Wells, 1999; Zolkower & Shreyar,

2007). To this line of research we contribute an exploratory inquiry on the effects of engaging beginning middle school mathematics teachers in the functional-grammatical study of spoken and written texts. As a unique spoken classroom genre which involves the interaction of multiple speakers positioned in asymmetric power/knowledge relationships, whole-class conversations pose heavy demands on teachers in terms of providing skilful conduction. In line with genre-based pedagogy (Martin, 1999, 2009; Rose, 2005), we guide participants to deconstruct exemplar of this text genre with the aim of developing their awareness of the range of semiotic choices they have available when conducting interaction—i.e. choices regarding diagramming, gesturing, discursive moves (e.g. evaluation, follow up, etc.), choices of grammar and vocabulary in the wording of their contributions, and so on.

Within our study, currently in midway, we are collecting audio and video data from participants' classrooms. We have constructed a rubric that identifies relevant features in the conduction of whole-group interaction which will be used to assess participant change along this dimension of their practice. We expect that our data will provide evidence that the guided reading of whole-class conversation texts strengthens teachers' ability to conduct the joint making of such texts in manners that are conducive to enlarging their students' mathematical meaning potential. The Necklace Text exemplifies the following three indicators from our rubric (Fig.1):

B.6: [The teacher] uses gesture (e.g. pointing) and demonstrative pronouns (*this, that, these, those*) and other deictic terms (e.g. *here, there*) to relate speech to the writing and diagramming that co-occurs on the blackboard or other writable surface; B.8: Her lexical and grammatical choices promote back and forth movements among material, mental/verbal, and relational processes; B.13: She makes functionally appropriate use of repetition, re-voicing, rephrasing (e.g. using targeted technical terms or, alternatively, rendering those into non-technical ones); and requests repetition and rephrasing from students.

Fig. 1

In the sections below, we sketch our theoretical framework, present the Necklace Text, and describe how the facilitator guided the reading of this text. This description is meant to illustrate our central claim, namely, that the guided deconstruction of whole-group interaction texts selected as paradigmatic instantiations of this genre strengthens teachers' awareness of their semiotic choices for shaping classroom conversations and the effects of these in promoting or hindering students' mathematical learning.

THEORETICAL FRAMEWORK

Our work relies upon a view of mathematics as mathematizing, that is, organizing subject matter with mathematical tools (Freudenthal, 1991). Following Freudenthal (1991), we conceive mathematics teaching as guiding students in *reinventing* mathematizing. And, inspired by Vygotsky (1978) and Halliday (1993), we value

skilfully conducted whole-class conversations as serving the function of ‘interpersonal gateways’ for enlarging the potential of what students can mean in the spoken, diagrammatic, and written language of mathematics.

SFL offers tools for explaining how speakers/writers use language to ‘realize’ (i.e. express, manifest) interpersonal, ideational, and textual meanings in texts (Halliday, 1994). Interpersonal meanings construe and/or maintain social relationships and perform communication roles; ideational meanings—i.e. material, behavioural, verbal, mental, existential, and relational—construe our experiences about the world around and inside of us; and textual meanings allow us to construe interpersonal and ideational meanings in texts. In whole-group conversations, ideational meanings pertain to the topic of conversation; interpersonal meanings concern the roles and relationships among the interactants; and textual meanings give cohesion and coherence to the conversation so it serves its intended purpose in the context wherein it unfolds.

The problem of how to support the development of student thinking within school contexts can be reformulated as how to initiate students into the “ways of saying: ways of meaning” (Hasan, 1996) privileged by school-taught disciplines. Among the six aforementioned types of ideational meanings, the relational ones are centrally implicated in the language of schooling (Schleppegrell, 2004) and, most conspicuously, in school mathematics (Morgan, 1998; Veel, 1999). Relational clauses, which are typically worded with the verb *to be*, relate two separate entities such that something is said to be something else, thereby realizing experience not as ‘doing’ (material) or ‘sensing’ (mental) but as ‘being.’ In other words, relational clauses make claims not about what happens or happened but about how things happen to be (Halliday, 1994). Teaching mathematics as an activity demands great skill from teachers in helping students turn material processes into relational ones as well as recover those material processes packed into relational clauses.

From an SFL perspective, analyzing a text amounts to explaining the meanings realized therein, accounting for how these meanings (as choices of grammar and vocabulary) fulfil interpersonal, ideational, and textual functions (Halliday, 1994). When analyzing a whole-class conversation text, we guide lesson study participants to consider the semiotic choices the teacher (in the text) made in her contributions to the text and relate what she said and did against the horizon of what she could have said or done.

THE NECKLACE TEXT

- 1 Teacher (T): Ok. The next one (*Draws: ●●○○●●○○●●○○●●... on the board*), the same question. What would be the colour of the 1000th bead?
- 2 Kaylan: We know that the tenth bead is black, right? The tenth bead is black... so I just timed it by 100 which got me to 1000.
- 3 Emily: Oh! Can I say something?

- 4 T: Wait, what Kaylan was doing, can anyone rephrase it in a different way?
- 5 Emily: I kind of used that pattern but...
- 6 T: No, no, no. You have to rephrase what he said in a different way first, before you can say anything else. Who can do that?
- 7 Carlos: What Kaylan said is that the 10th bead is black, right? So, if you times it by one hundred, you will get 1000 beads. The 1000th bead will be black.
- 8 Melika: So, basically he's saying that the 1000th bead will be like the 10th one.
- 9 T: Mm.... someone sees something yet?
- 10 Leah: He said that he timed it by 10 and then he did 10 groups of 100-
- 11 T: Wait, wait. What did Kaylan do? What was he doing here? He counted up to 10 and then MENTALLY he SNAPPED it off, right? (*Makes a hand gesture indicating cutting with scissors*) He made a cut.
- 12 Nyree: Yes!
- 13 T: Ok, so, let's make a cut. Let's do that. Let's make a cut. (*Draws a vertical line between the 10th and the 11th bead: ●●○○●●○○●●|○○●●...*). But, what happens after you cut that?
- 14 Emily: But look at this! (*Walks toward the board*) This (*points to the first black bead*) is starting with a black but now (*points to the 11th white bead*) it starts with a white. They don't start with the same color. See?
- 15 T: So, if that's the case, can we multiply it by 100 and say it will be the same?
- 16 Chorus: No!
- 17 Melika: No, because the results will change.
- 18 Emily: Can I say something?
- 19 T: Can she say something?
- 20 Chorus: No!
- 21 T: Alright, Nyree first, and then you.
- 22 Nyree: Like... you know, like... we said before that half of the 1000 beads is 500, right? But then, like he said, if you cut it up to 10, the other one will start with white, but if half of 1000 is 500... What if we separate it from the 5th one?
- 23 T: Separate it from the 5th one? That's interesting. If I have to snap it off... if I want to cut this very long necklace into chunks of little, little sections (*makes a hand gesture indicating cuts on the drawn necklace*), how should I cut it?
- 24 Chorus: By 4!/By 5s!
- 25 T: By 5 or by 4? I have two suggestions so far (*With different colour markers, draws vertical lines on the necklace to signal the two proposed cuts*).
- 26 Leah: By 4. If you cut it by 5s, each group has the same amount of color beads but the two groups are different so--

- 27 T: So, wait. This is what Leah suggests. She suggests we chunk it like this (*points to chunks of 4*) because--
- 28 Emily: That's what I was going to say! You see? You don't let me say anything!
- 29 T: (*Smiling at Emily and making a hand gesture signalling that she waits*). What do you think now, Nyree, should we cut it by 4s or by 5s?
- 30 Nyree: By four!
- 31 Emily: Yes. I think you should cut it by 4s!
- 32 T: Ok, Emily.
- 33 Emily: (*Walks to the board*). I noticed the pattern right here, that every fourth bead is a white bead (*pointing to the 4th, the 8th, and the 12th bead*). This set of 4, right here, the last one is always white. So, I know that... it's a multiple of 1000 so...
- 34 T: Wait, wait, wait. Four is a MULTIPLE of 1000 or?
- 35 Emily: A factor, a factor of 1000.
- 36 T: Oh! Ok, Melika.
- 37 Melika: I think you should cut it by 4s.
- 38 Cathy: No. I think you should cut it by 5s.
- 39 Melika: If you cut it by 5s, then you would be ending with a black bead.
- 40 T: Also... are these the same, though? Are these chunks the same? (*Pointing to the chunks of 5 on the necklace*)
- 41 Chorus: Yes! No!
- 42 T: Black black white white black.... Black white white black black. Are they the same?
- 43 Chorus: No
- 44 T: So, would that be alright?
- 45 Chorus: No!

GUIDING THE INTERPRETATIVE ANALYSIS OF THE TEXT

In prior sessions, the study of other texts (cf. de Freitas & Zolkower, this volume) served to exemplify technical SFL-related vocabulary: turn (change of speaker); clause (smallest linguistic expression with meaning in itself); speech function (questions, statements, and commands); grammatical form (interrogative, declarative, and imperative); and congruency (alignment between the grammatical form of a clause and its speech function). Of the six participants in the sub-group in which the Necklace Text was read, 3 had been in the project from the start (Dolores, Sarah, and Nyoka) and the other 3 (Jason, Karin, and Michelle) were newcomers.

Before reading the text, the group explored necklaces with repeating and recursive patterns—e.g. BBWWBBWWBBBBWWBBBBWWBB..., and BWWBBBBWWWBBBBB—in light of the question: *Imagine we were to continue*

this necklace, following the same pattern. What would be the colour of the 1000th bead?, and then identified the mathematics embedded therein (odd and even numbers, factors and multiples, and remainders; repeating vs. recursive patterns; and structuring, symbolizing, generalizing, and predicting). The facilitator (BZ) contextualized the text by offering the following information: the teacher (Ms. L) had 16 years of teaching experience; the conversation under analysis involved a heterogeneous 6th grade class of 22, with Latino, African-American, and Asian background students exhibiting a wide range of academic performance levels; the lesson took place in March; the academic performance levels of the students who participated vocally in the conversation were as follows: High: Kaylan and Leah; Medium: Carlos and Emily; and Low: Nyree and Melika, and Cathy (special needs).

The questions that framed the text analysis were: What is the teacher doing and saying? What is the grammatical form and speech function of her contributions? How does she guide the students in making mathematical meanings? If you were the teacher in this class, what would you have done or said differently and why?

First, participants were instructed to read the entire text and write down what they found interesting. After ten minutes, BZ focused everyone's attention to the number of turns in the text (45) and the distribution of student and teacher turns—teacher: 19; students: 26, with 7 students who spoke on their own and 6 chorus responses. It was noted that the number of vocally participating students was about one third of the class, in approx. 15 minutes. The dominance of the present verb tense—a total of 84 verb occurrences; past: 10; future: 5; present (simple or continuous): 69—was read as grammatical evidence that the conversation was not about reporting on work previously done but consisted of “thinking aloud together,” in the moment, and under the teacher's guidance (Zolkower and Shreyar, 2007; Shreyar, Zolkower and Pérez, 2009). Next, the presence of diagrams and italics (for non-verbal actions) was read as indicative of the multimodality of the text.

With regards to turns 18-21, Sarah asked: “Do they have like... a deal in this class, like Emily can't talk until like four other people talk? [...] I think that's great. I'm definitely going to try that in my classroom.” BZ: “Most likely, this rule was established at the beginning of the year and has now become implicit. Definitely the teacher doesn't want any kid to dominate. She wants to control the discourse. Although she wants everyone to participate and appreciates what people have to say, she does not want them to say whatever they want at any moment.” How did Ms. L. control the conversation? Offering a few examples from the text, BZ underlined that she did so via interrogatives (yes/no as well as ‘wh’ or open) and imperatives and that, for the most part, there was congruency between the grammatical form of her clauses and their speech function. Nyoka noted the presence of ‘if... then’ questions in teacher ([15], [23]) and student contributions ([7], [22], [26], [39]), and this was read as evidence of logical-mathematical thinking.

The facilitator described turns 4 and 6 as requests for rephrasing, the former realized with low and the latter with high modality (“can anyone rephrase...”; “you have to

rephrase...”). Participants offered differing interpretations of the rationale behind this request: “to reinforce students’ literacy skills,” “to check that they understand,” “maybe if they hear it again someone would catch the error,” “to make sure everyone is paying attention.” These interpretations, which speak volumes of the purpose participants attribute to whole-group interaction, seem at odds with the view of this conversation as a thinking aloud together text.

With respect to turn 9, Nyoka wondered: “I’m just was curious as to what motivated her to say that and to say it in that way.” Sarah: “It’s like she’s challenging other senses: what do you *see*?” BZ: “In looking ahead at her turns 11 and 13, it seems that Ms. L. means: Let’s take a closer look at the necklace so we can see that we can’t just infer from the fact that the 10th bead is black that the 1000th bead will be black as well.” It was noted next that, in turn 11, the teacher reacted to Leah’s rephrasing with a question realized with the verb *to do* (material process) and answered it herself, a hand gesture, a mark on the diagrammed necklace and an interrogative question demanding a process of *happening*.

Regarding turn 14, participants commented that Emily was finally was allowed to speak and that now her contribution fitted well in the text. BZ commented that, in turn 15, the teacher used an ‘if... then’ clause to complete Emily’s statement by making explicit what she had left out. Yet, in Nyoka’s view, this question was “too leading.” BZ: “Yes. We can read it as a statement in the grammatical form of a question, not a true question, as if saying: Are you all with me now?” Karin wondered, with regards to student turn 17, “Why isn’t the teacher asking her what she means?” Jason responded: “Maybe she was going to, but Emily got in the way.” Sarah: “If you look at Emily’s use of pronouns: *I* and *me*, in turn 28, the teacher is trying to elicit the entire class to remind her, this is not just for me, this is what you’re doing for the entire class. But her language is saying: you, the teacher, you are not letting me talk.” BZ: “How do we have a conversation in which *I/me*, *he/she*, *his/her*, and the individual *you* are less important than what *we* are doing, here and now, together?” Nyoka, who teaches in an all-girls middle school, shared: “I have a room full of Emilys [...]. They sit in triads and I just let them talk to each other... like they’re gonna talk to each other anyway. I don’t want them all yelling at me. So, I say: Take a moment and talk to each other about the math, what is going on here?”

With regards to Nyree’s suggestion (turn 22) to “separate it from the 5th one,” Sarah observed: “You can tell that Nyree is listening. She got the point that the chunks have to start with the same colour.” When BZ highlighted that, in turn 23, the teacher contributed the most important question, Jason observed that Ms. L. interrupted Leah [26-27] and wondered why she did so. Nyoka: “Because what she’s about to say is going to go over everyone else’s head.” BZ: “Yes. Her interruption served to chunk Leah’s argument, which she worded with two ‘if... then’ conditionals: if you cut it by 5s, if you cut it by 4s. Just as the teacher was chunking the necklace, she was also chunking the talk, to distribute it throughout the class.”

Participants' attention was next focused on the verb choices throughout the text. The initial question, "What *is* the colour of the 1000 bead?" requested a relational process. In response to Kaylan's suggestion, the teacher asked: "Someone *sees* something yet?" whereby *sees* can be read as calling for a mental or a behavioural process (*seeing* as realizing or as viewing or noticing). Later on, Ms. L. reworded Kaylan's contribution as a process of doing ("What did Kaylan *do*?"), mentally snapping off the necklace in groups of 10, and inviting the class to "make a cut." Dolores noted that, in turn 42, the teacher's reading aloud of the pattern allowed the students a chance to "hear" the repeating chunk. As to turns 40, 42, and 44, Sarah commented: "Instead of asking the same question twice, three times, I would have asked: If you say they are the same, how are they the same?"

The group then was led to reconstruct the mathematics in the Necklace Text as a sequence of relational clauses: *What is the relationship between 4 and 1000? How can I use this relationship to predict what colour would the 1000th bead be? The length of the repeating pattern is 4. 1000 is equal to 4 times 250. A 1000th bead necklace with that pattern will be made of 250 identical chunks, each of length 4. The colour of the last bead in the repeating pattern is black. Therefore, the 1000th bead will be black.* Moving away from the text, the discussion ended with the exercise of defining, via relational clauses, mathematical notions (nouns) volunteered by the participants ('slope,' 'square root,' 'order of operations') and then unpacking their meaning by recovering the processes (verbs) encapsulated in them.

Below (Fig. 2) are participants' comments on the Necklace Text (end-of-the session written feedback form).

"The way they use language is so concise. And there's so much math in the dialogue without anyone talking a lot." "I was impressed with how the teacher controlled the discourse so it stayed within the students' zone of proximal development." "Using action verbs like cutting, chunking, breaking apart, creates greater meaning for mathematical ideas. The teacher created opportunities for students to move between material (doing) and relational (being) processes." "The conversation moved very smoothly, even when the teacher corrected a vocabulary error. I like how she does not evaluate right away what students are saying. Sometimes I find this very difficult to avoid." "You can use necklaces for teaching multiples and factors and developing number sense. There is also algebra in them: odd and even, using letter symbols, generalizing, making predictions, and so on."

Fig. 2

As described above, throughout the activity, participants were guided to describe and explain the semiotic choices made by an experienced teacher working in a heterogeneous classroom and to consider the effect of these choices in supporting movements back and forth between doing, happening, looking, seeing, noticing, saying, having, and being. Engaging with the Necklace Text served as a productive encounter with a paradigmatic text of the genre of whole-class interaction which

functioned as an exemplar of how teachers and students can think aloud together, mathematically and about mathematics.

The documentation of our lesson study sessions is yielding evidence that engaging beginning teachers in the functional-grammatical study of whole-class conversations shifts their perspective and attitude away from just commenting on the texts towards first analyzing and only then evaluating them, with an eye towards imagining alternative teacher contributions. As expected, this is not an immediate and uniform process; instead, it is one that happens rather slowly, at different paces and in a different manner for each of the group participants.

CONCLUSION

The quality of mathematics education in general and, in particular, that of students from low SES and other non-dominant social groups may be improved by creating opportunities for teachers to learn how to shape whole-class conversations as interpersonal gateways for students to learn how to think mathematically by thinking aloud with their peers under the teacher's guidance. This professional development model involves guided deconstruction of paradigmatic texts of that genre, with opportunities for teachers to participate in the joint making of such texts as they interact with peers and facilitator around non-routine problems. These interconnected experiences of joint text deconstruction and construction prepare teachers to support the making of spoken and written texts in their own classrooms (Martin, 1999).

As we continue generating and processing project data, we expect to demonstrate that our approach equips beginning teachers with semiotic tools for enacting hybrid pedagogies in their classrooms. Gleaning from Bernstein's (1990) theory of pedagogical discourse and its applications to teacher education (Morais et al., 2001), by this we mean engaging students in framing, solving, and reflecting on non-routine—hence, weakly classified—mathematics problems yet offering waves of strong and weak framing that guide their interactions with teachers, peers, and texts.

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