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Classroom Mathematics Discourse in A Kindergarten Classroom

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This study provides an analysis of classroom discourse at the kindergarten level. We illustrate how young learners can participate in mathematics discourse and how the teacher can support their engagement. The teacher in our study played a crucial role in supporting students' talk through practices that promoted collaboration around important mathematical ideas, and the provision of resources that allowed students to communicate about their reasoning with others.

Classroom discourse is integral to mathematics instruction at all levels. The expectation that all students will engage in mathematics discourse is central to the Common Core State Standards, which emphasize practices like conjecturing, justifying, and reconciling different ideas to analyze a problem situation (CCSSI, 2012). This work is challenging at all levels, but perhaps especially for very young learners who are still developing their general oral language skills while at the same time beginning to acquire academic language.

Learning mathematics in the early years is tied to students' development of language and communication skills (Greenes, Ginsburg, & Balfanz, 2004). In mathematics, in particular, research suggests that children as early as kindergarten can consider alternative strategies and are capable of sophisticated mathematical thinking (Carpenter, Fennema, Franke, Levi, & Empson, 2014). Classroom mathematics discourse requires not only that students have the language facility to participate in general discussions, but more specifically that they are able to use language to communicate reasoned academic mathematical messages that others can understand and respond to. The teacher has a critical role in supporting student engagement in such practices, and research in mathematics education provides helpful insights into the work that teachers do in such a role. However, there is very little research on how students as young as kindergartners engage in mathematics discourse and how teachers support them in the process given their level of mathematical and linguistic development. Our work in this study aims to address this point. We use the case study of a kindergarten classroom to examine the questions "How can kindergartners participate in mathematics discourse? How can teachers support kindergartners' mathematical discourse?" Our findings highlight the way kindergartners can draw on resources available to them as young learners to engage in making mathematical claims and providing explanations. We highlight two main aspects of the teacher's work in supporting the students' discourse: her use of resources that facilitate mathematical communication, and her promotion of collaboration among the kindergartners around key mathematical ideas.

Theoretical Framework

A socio-constructivist perspective on mathematics teaching and learning frames our views of discourse and its development in the classroom (Cobb, 1994). Students' collaborative engagement in mathematics discourse supports their construction of an understanding of mathematical concepts and fosters their disposition to see mathematics as sensible and worthwhile (Michaels, O'Connor, & Resnick, 2007). Developing this level of intellectual work

by young children requires intentional work on the part of the teacher, who among other things needs to "provide a range of experiences, opportunities, resources and contexts that will provoke, stimulate, and support children's innate intellectual dispositions" (Katz, 2015).

Our interest in the central role of the teacher in supporting students' development of discourse is grounded in three teaching commitments, identified by Ball and Bass (2003) as: the *integrity of the mathematics*, the *collective as an intellectual community*, and *taking individual student's thinking seriously*. Teachers attend to the integrity of mathematics through the promotion of mathematical ways of reasoning when they press students for conceptual thinking that emphasizes not only the sharing of strategies but also explanations and justifications. Attending to the work of the community as a collective rests on the assumption that mathematical knowledge is socially constructed and validated. Helping students to engage in collective mathematical activity requires supporting their abilities to listen to and represent others' ideas, even those with which they disagree. Teachers convey their attention to student thinking in the way they hear or see the mathematical details of students' strategies, and highlight them for other students, using various representations.

Methods

The study focuses on Ms. Sanders (pseudonym), a kindergarten teacher who participated in a larger study of K-5 mathematics teachers and their enactment of ambitious teaching practices. About 65% of the students at Ms. Sanders' school are economically disadvantaged, and about 6% of the students are English Language Learners. Ms. Sanders' students are representative of the demographics of her school. The ambitious nature of discourse that was evident in her class motivated us to conduct a more in-depth analysis of her practice.

We created video transcripts of four mathematics lessons from Ms. Sanders' classroom collected over the course of one academic year. Focusing mainly on the whole class discussion part of the lessons, we used grounded theory (Glaser & Strauss, 2009) to thematically code the transcripts, noting patterns in students' mathematical communicative practices and the teacher's work in supporting their discourse. We grouped these patterns into categories that reflected the students' participation structures and Ms. Sanders' instructional approaches in supporting their mathematical discourse in ways that attended to the three commitments in our theoretical framework. We each individually examined the data for themes, and then met as a research group to confirm or disconfirm our findings, and negotiate our disagreements.

Findings

Our analysis revealed that the students in Ms. Sanders' classroom consistently engaged in mathematics discourse during whole-group instruction. The following practices characterized the participation structure: (1) Students consistently explained their thinking using various resources around the classroom; (2) Students followed established classroom norms, which promoted engagement in productive mathematics discourse. These norms included sharing ideas and attending to errors respectfully, and listening and responding to one another's thinking; (3) In response to Ms. Sanders' questions, students would share solutions to a problem, explain the reasoning behind their solutions, and work collaboratively to increase the clarity and sophistication of their explanations with the help of both the teacher and other students.

Our analysis of the ways Ms. Sanders supported her students' participation in mathematical discourse found that she leveraged two main categories of work: (1) using - and orienting students to - resources that facilitate mathematical communication, and (2) promoting collaborative work around the mathematics in a way that is responsive to student thinking. Ms. Sanders' facilitation of whole group discussion also followed a consistent pattern in which she

solicited various student solutions to a problem, pressed them for explanations, and oriented them to each other's ideas by asking them to restate someone's idea or explain someone's reasoning. In the process she used verbal and written representations to support students' explanations and reasoning, and infused more precise use of language into the discourse. In the following sections we describe the role of both the teacher and students in the use of resources to communicate ideas and in collaborative work on mathematics.

Using Resources

Ms. Sanders and her students consistently drew on a variety of material and conceptual resources in communicating their thinking. Material resources include displays (eg. number lines), pictorial representations and manipulatives. Conceptual resources consist of common language (eg. math words and symbols) and a taken-as-shared knowledge base built around students' ideas. In our analysis, we noted three specific ways Ms. Sanders supported her students' mathematics discourse with resources: (1) She made resources available around the classroom and physically within the students' reach, (2) She established the norm of moving freely around the room to seek resources to support one's thinking; and (3) She frequently oriented students to resources they could use in supporting their explanations.

In several instances of our data, we noted how students used resources in their explanations both as a direct response to a teacher's suggestion and through their own spontaneous initiative. As an example, in one lesson, the students were sitting in front of a pocket chart where the number of days the class has been in school was represented with bundled sticks (100s, 10s, 1s). They had just counted collectively 9 sticks in the ones' pocket. Ms. Sanders asked them "how many days until we make another group of 10?" A student, Aiden, replied "one." When asked to explain, Aiden stood up and pointed to the 9 on a hundred's chart that was hanging on the side of the board. He stated, " Because this is when we start, [then pointing to the 10 on the hundred's chart] and this is when we put 10." Here Aiden did not use the hundred's chart per the teacher's request, but readily reached for it to support his thinking. Our findings suggest that such behavior was typical of other students' use of resources in this class while explaining their thinking. Ms. Sanders' use of the phrase "group of ten" is an example of the way she orients students to available conceptual resources. Later in this discussion, Aiden uses this language to more clearly explain his thinking.

Collaboration around the Mathematics

Ms. Sanders facilitated students' participation in discussions by promoting expectations for sharing one's reasoning. For example, Ms. Sanders would often say to the students, "Be ready to share with us how you knew that your answer was correct." Furthermore, she facilitated discussion among the entire classroom community by consistently orienting students to each other's thinking, asking students to evaluate their classmates' assertions and apply their reasoning to others' ideas. More specifically, Ms. Sanders supported the kindergartners' participation in these practices by often narrating a student's thinking before orienting others to it. She also consistently inserted specific mathematical language during her narration to teach students how to communicate reasoned mathematical messages. The following excerpt illustrates Ms. Sanders's use of these practices. The excerpt continues from the example provided above, where after Aiden explained his reasoning in relation to "how many days till we make a ten?" by pointing to the hundred's chart, the teacher moved the chart to the center of the board and pressed Aiden to clarify his thinking.

Ms. Sanders: What do you mean this is where we start, Aiden? Why do you start at 9?

Aiden: [Pointing to the ones' place of the pocket chart with bundled sticks] That's our one.

Ms. Sanders: So Aiden is looking at the ones' place and he found that we have 9 ones today. And then what did you say next, Aiden?

Aiden: You take one more hop and you make a group of ten.

Ms. Sanders: So he says, "one more hop, and we make a group of ten." [Looking at the class while pointing to the 10 on the hundred's chart] How does Aiden know that we're making a group of ten? Isabel, what about that number tells us that we are making a group of ten there?

Isabel: Because we are having one more hop.

Ms. Sanders: Ok, can someone add on? She said, "We've got one more hop." How do we know we've got a group of ten here?

The excerpt illustrates the way Ms. Sanders's used Aiden's thinking as a resource for helping the class attend to the idea of place value. By pushing the hundred's chart the center of the board, she legitimized his use of such resource to explain his thinking. She also supported Aiden's explanation by revoicing it with more precise language, inserting the notion of "the ones' place" and repeating the key idea of "a group of ten" intentionally during the exchange. Her press to have Aiden clarify his reasoning supported him in being able to provide a reasoned mathematical message using more precise language. One can note, for example, how Aiden responded to Ms. Sanders above by saying, "You take one more hop and you make a group of ten." Her call on several students to build on each other's efforts in explaining Aiden's reasoning reflects her commitment to the work of the class as an intellectual community.

Discussion and Conclusion

The case of Ms. Sanders provides an existence proof that kindergartners are capable of engaging in sophisticated discourse, but to do so, they need specific supports that build on their developing knowledge and communication skills as young learners. Ms. Sanders acted intentionally to gently guide discussions toward more precise language and mathematical ideas. Her use of narration and repetition of key mathematical points were aspects of her work that we found to be supportive of students' participation in mathematics discourse.

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