Supporting Mathematical Discussions with Discourse Practices and Learning Support

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Abstract

This study details the complex nature of teachers' role in helping students to participate in mathematics discussions. Guided by Wenger's (1998) framework of *community of practice*, the teacher's use of discourse practices and provision of learning support, in particular tasks and tools, are examined to better understand the kinds of opportunities they afford to socialize students towards mathematics competence. One urban fifth-grade mathematics classroom was observed during a mathematics unit on finding the area of geometric shapes. The data sources included videotaped classroom observations, instructional materials, and student work. The unit of analysis focused on the role discourse practices and learning support play in facilitating the teacher-student interaction. The finding illustrates that the teacher's use of discourse practices and her provision of learning support promoted multiple modes of communication: oral, writing or drawing, and gesturing. The nature of the *tasks* and the availability of *tools* also opened up multiple avenues through which students were able to access key conceptual ideas in the mathematical problem or the teacher's discourse. By having these tools available and witnessing the teacher incorporating them in classroom discourse, students are also given multiple ways of communicating their mathematical understanding.

Keywords: Mathematics discussion, learning support, discourse practices

1 INTRODUCTION

This study aims to capture the discourse practices and learning support a teacher used to interact and negotiate mathematical meanings with students, and to understand how these practices create opportunities for students to participate in the construction, transformation, and application of mathematical knowledge. Teachers play a significant role in shaping mathematical discourse by defining what mathematics is and what it means to do and know mathematics. Thus, the discourse practices that teachers use to engage students have significant implications on how students come to relate to teachers, one another, and mathematics (Franke, Kazemi, & Battey, 2007). Thus, to learn more about how to best support students in mathematical discussion, it is imperative to study the ways teachers are structuring entry points for students to become a part of the classroom discourse. This study will follow a specific line of inquiry: How does the teacher use discourse practices and provide learning support to construct opportunities for students to participate in mathematical discussions?

2 LITERATURE REVIEW

(2.1) Discourse Practices

This study's focus on teaching practices in relation to student participation is guided by a social theory that characterizes learning as "increasing participation in communities of practice" (Forman, 1996; Greeno, 1998; Lave & Wenger, 1991; Wenger, 1998). To place practice in context, this study uses Wenger's (Wenger, 1998) conception of *Community of Practice* as the overarching theoretical framework. In particular, this study focuses on classroom discourse and social interactions between a teacher and her students to better understand how knowledge is constructed and how students are best supported. Various forms of discourse practices have been studied to understand how they create opportunities for students to participate in learning. This study looks at three particular discourse practices – *questioning*, *revoicing*, and *gesturing*.

Questioning is a predominant form of instructional practice that teachers use to orchestrate classroom discussions. In the recent years, a number of researchers have started to study alternative uses of questions that support student discourse and understanding. Questions can be used to align students in mathematical argumentation (Forman, Larreamendy-Joerns, Stein, & Brown, 1998; O'Connor & Michaels, 1993, 1996), model the academic discourse (Ball, 1993; Lampert, 1990; Moschkovich, 1999), and socialize students to larger mathematics discourse (Lampert, 1990). Moreover, the study by Hiebert and Wearne (1993) also found out that teachers who ask more high-level questions that require longer explanations and deeper analyses foster greater conceptual understanding in students. These high-level questions require more intellectual work from students and provide more opportunities for teachers to identity the struggling students and pinpoint the areas that are not making sense to them (Hiebert & Grouws, 2007). In more recent studies, Franke, Webb, and their colleagues explored the relationship between teacher's instructional practices and the nature and extent of students' explanations in collaborative settings. Their findings suggested that asking questions to probe students' explanations positively correlate to the development of student thinking and problem-solving strategies (Franke, Webb, Ing, Chan, & Freund, 2007; Webb et al., 2009). The Cognitively Guided Instruction (CGI) study conducted by Carpenter et al. pointed out that the work of listening and paying attention to student thinking needs to couple with these questioning practices in order to determine what follow-up pedagogical actions can scaffold students' conceptual understanding.

Revoicing can be used to facilitate student participation in many ways. First, it can open up opportunities for expanded, iterative evaluations between the teacher and student on an original student response in order to achieve mutual understanding and minimize

misinterpretation (Moschkovich, 1999). Second, it can model the academic language by rephrasing or translating the student's response to reinforce specific mathematical terms (Enyedy et al., 2008; Moschkovich, 1999). Third, it can occur in the usage of certain words, such as *so*, to warrant others' utterances or in the evaluation stage of an I-R-E sequence by the teacher who repeats a student response to affirm its correctness (O'Connor and Michaels, 1993, 1996). Lastly, revoicing can be used to position the original speaker "in relation to others, the task, or the original speaker's interpretation of their own utterance" (Enyedy et al., 2008).

In the past fifteen years, there has been a growing body of research looking at the role of gesture in student learning in collaborative or independent settings, yet there has been comparatively little research on the role gesture plays in teacher-student interactions. Two empirical studies by Castellon and Enyedy (2006) and Valenzeno, Alibali, and Klatzky (2002) have started to study how teachers' gesturing relates to student learning and participation in mathematics classrooms. Their findings affirmed some of the teaching implications gathered from the student-oriented literature, which indicate that gesturing is a "meaning-making resource" that can be used by teachers to facilitate interactions and enrich classroom discourse in various ways. First, gesture can provide an additional layer of meaning to increase access to teacher talk when the mathematical or English language is unfamiliar to students (Castellon & Enyedy, 2006; Reynolds & Reeve, 2002). Second, gesture can be used to interpret or assess student's problem-solving strategies and mathematical knowledge (Alibali, Flevares, & Goldin-Meadow, 1997; Roth, 2001). Third, gesture can be used to attain and sustain joint attention on the communicative activity (Goodwin, 1986; Reynolds & Reeve, 2002). Fourth, gesture can be used to align with student talk to highlight important mathematical concepts (Castellon & Enyedy, 2006).

(2.2) Provision of Learning Support

Mathematical knowledge is socially constructed and negotiated. What it means to know and learn mathematics does not emerge solely from textbooks, worksheets, or manipulatives. It is embedded in the roles and responsibilities the teacher and students take up in classroom discourse (Ball, 1993; Lampert, 1990). Through discourse and interaction, the teacher and students construct meanings out of these artifacts. It is through this discursive process of mutual engagement that practices take on meanings and indicate roles of participation. "The repertoire of a community of practice includes routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions, or concepts that the community has produced or adopted in the course of its existence, and which have become part of its practice" (Wenger, 1998, p. 83). The shared repertoire becomes the tools and resources the teacher and students draw upon to negotiate meaning in mutual engagement. In a mathematics classroom, students make sense of mathematics by using a variety of practices that they are familiar with and competent in from their other communities. When a variety of practices are brought into the classroom community by individual participants, the community as a collective body negotiates and determines the inclusion or exclusion of these practices. The repertoire of practices is ratified through these histories of introduction, negotiation, legitimization, and appropriation.

3 METHODS

A *case study* design is used to offer intensive, holistic descriptions of teacher-student interaction to record in detail what was being communicated and practiced, and how and when these processes occurred given the contextual dimensions. A fifth-grade classroom at an urban elementary school was selected to be the research site for the study. The major

participants[1] of the study were one teacher and six of her students. Ms. Soto had been teaching for eleven years at CES. Out of the 25 students in the classroom, I followed six students closely to gain an in-depth look at their interactions with both the teacher and the academic content.

The two foci on teacher's discourse practices and students' engagement were embedded in a broader understanding of learning support that come to organize the interactions and practices. In particular, I identified two forms of learning support. First, I identify the *tasks* that the teacher assigned to the students. The tasks were important because they provided the context for student learning and orchestrated all the interactions around them (Doyle, 1988). As defined by Hiebert et al. (1997), the kinds of tasks that build mathematical understandings are those that promote reflection and communication, integrate concepts and procedures, and allow students to use a diversity of tools and resources. Second, I identify the *tools* that were introduced, legitimized, and used to support the teaching and learning in the community.

I observed the mathematics class for nine consecutive days for the entire duration of a cohesive mathematics unit on finding the area of geometric shapes. The videotaping focused on the interactions between the teacher and the target students. Instructional materials and student work were also collected to understand the context of mathematics instruction.

4 RESULTS

In teaching area, Ms. Soto made a variety of tools and resources available for the students to construct meanings for key mathematical ideas. Grid paper was used to facilitate the counting and moving strategies students used to make sense of the concept of area (Appendix A). Students also used both informal measurement units (tiles) and formal measurement units (rulers and measuring tapes). Tools afforded multimodalities in classroom discourse, enhancing the construction, communication, and negotiation of mathematical meanings. Consequently, tools came to shape the way students understood the concept of area.

Here, I present an excerpt to elucidate how square-inch tiles (Figure 1) were used to facilitate the reconstruction of knowledge in finding the area of triangles.



Figure 1: Square units

The students in this excerpt were working finding the area of a right triangle with a height of 2 inches and a base of 1 inch (Figure 2).

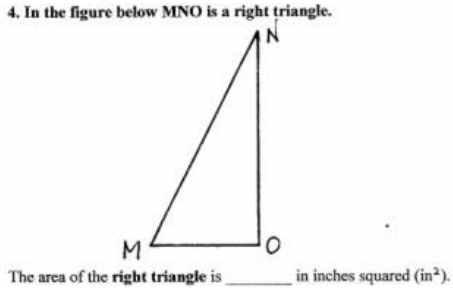


Figure 2: The problem on the area of a right triangle on the review worksheet

[1] All names of the participants have been replaced with pseudonyms not bearing similarity to their real names.

Some students, including Diane and Helen, forgot to multiply by 1/2 after measuring and multiplying the base and the height together. This excerpt was selected to show how the teacher used tiles to assist the students in thinking about Helen's error (line 6):

Excerpt: "Could you get me two tiles?"

1	Helen:	*[Measures the height]* Ms. Soto, look, 2.
2	T:	Ok.
3	Edward:	And the base is 1.
4	Helen:	And the base is 1.
5	Diane:	So 2 times 1 is 2.
6	T:	So, let me see, the area of a triangle is 2. *[looks at Helen's paper]* So you did base times height.
7	Charrissa:	And a half of 2 is 1.
8	T:	*[Not hearing Charrissa's utterance]* I don't know. Could you get me 2 tiles? I'm just visualizing this. Could you get me 2 tiles? *[Edward goes to get them]* I don't think I can fit 2 tiles there.
9	Charrissa:	No.
10	Helen:	No, you can't.
11	T:	So, what am I forgetting? *[Edward gives T the tiles]*
12	Diane:	The half. The half. The half *[taps the desk]*
13	T:	Mainly, what are you forgetting?
14	Helen:	Oh, the half.
15	T:	You're telling me 2, this is what you're saying. *[places two tiles on top of the right triangle]* Is that accurate?
16	Someone:	No.
17	T:	So how about if I do this. *[First attempt to draw something but drops the pencil]* Well, what can I do to figure it out?
18	Diane:	It's a whole.
19	Helen:	You could ( ) in a half.
20	T:	Charrissa did the tracing. I'm gonna use Charrissa's strategy on tracing. Charrissa, are you ok with that?
21	Charrissa:	Yes.
22	T:	I'm gonna go like this, so I can visualize it in my head. *[holds the tiles and traces]* Oops, oh, now I can fit two tiles in there. *[erases]* Ms. Soto is the ( )



Figure 3: Teacher places two tiles over the triangle and traces around them

23	Diane:	Ms. Soto, it's a half, it's a whole.
24	Charrissa:	Ms. Soto, look it.
25	Edward & Diane:	It's a whole.
26	Helen:	It's a ( ).

In line 6, the teacher revoiced Helen's incorrect written work; and later asked Edward to get two units of square-inch tiles to find out if two tiles could fit in the triangle. The teacher

clued Helen that she forgot something. This example shows how the teacher used concrete objects to get the students to notice what was wrong about their original incorrect thinking (line 22, Figure 3). Diane replied in a loud voice, "the half, the half, the half" (line 12). After hearing Diane's response, Helen let out a loud "Oh, the half," signifying her repair. Even though Helen recognized the major source of her error, the teacher continued on to finish her demonstration with the two tiles by placing the tiles over the triangle and tracing around the tiles.

5 DISCUSSIONS

Both the teacher's discourse practices and her provision of learning support promoted multiple ways of talking about mathematics. In mathematical discussions, teachers used multimodal discourse practices of questioning, revoicing, and gesturing that draw on three basic modes of communication: *oral* communication, which relied on the use of speech; *written* representation of ideas; and gesturing, a *visual* and *kinesthetic* representation. This multimodal discourse opens up diverse entry points for students to access and comprehend the words and actions of teacher discourse; and thus, opening up opportunities for students to engage with the content and contribute to the mathematical discussions.

Tasks and tools are the key supportive contextual elements that allowed multimodal communication to take place. In exploring area, the tasks were posed in the context of teacher designed and -selected materials of grid paper, tiles, geometric shapes, concrete objects, and measuring units. As shown in the example provided above, these learning supports became an integral part of the mathematical discourse. Thus, it is important for teachers to choose or design mathematical tasks that are conducive to flexible use of strategies and provide tools as communicative agents for the teacher and students to express ideas and construct thinking .

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Appendix A – Examples of the use of grid paper as a tool to explore the concept of area in lessons other than the one described in the paper.



