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National Center for Research on Evaluation, Standards, and Student Testing

Graduate School of Education & Information Studies
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THE ROLE OF TEACHER DISCOURSE IN EFFECTIVE GROUPWORK[1]

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Abstract

Prior research on collaborative learning identifies student behaviors that significantly predict student achievement, such as giving explanations of one's thinking. Less often studied is how teachers' instructional practices influence collaboration among students. This report investigates the extent to which teachers engage in practices that support students' explanations of their thinking, and how these teacher practices influence the nature of explanations that students give when asked by the teacher to collaborate with each other. In this study, we videotaped and audiotaped teacher and student participation, and measured student achievement, in second- and third-grade mathematics classrooms working on algebraic concepts of equality and relational thinking. The teachers observed here, all of whom received specific instruction in eliciting the details of student thinking, varied significantly in the extent to which they asked students to elaborate on their suggestions. This variation corresponded strongly to variation across classrooms in the nature and extent of student explanations during collaborative conversations, and to differences in student achievement.

Introduction

Many current conceptions of learning, especially social-cognitive and social-constructivist perspectives, highlight the central importance of student participation in social interaction. In Vygotsky's (1978) view, for example, people learn of concepts and strategies during interaction with more knowledgeable others and then internalize them. Expressing and defending their beliefs and opinions and questioning others' ideas helps learners to recognize, clarify, and repair inconsistencies in their own thinking (Ball, 1993; Cobb, Yackel, & Wood, 1992; Hatano, 1988; Lampert, 1989). Similarly, Leont'ev's (1978) activity theory argues that participation in social practices significantly influences an individual's psychological development, that changes in individual activity development serve as a catalyst for changes in the social activity, and that neither exists without the other (Minick, 1989).

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Not any kind of student participation is expected to be productive for learning, however. Both theoretical and empirical literature support the power of giving explanations compared to other kinds of participation such as giving answers. Researchers theorize that giving explanations to others promotes learning by encouraging the explainer to reorganize and clarify material, to recognize misconceptions, to fill in gaps in his or her own understanding, to internalize and acquire new strategies and knowledge, and to develop new perspectives and understanding (Bargh & Schul, 1980; King, 1992; Peterson, Janicki, & Swing, 1981; Rogoff, 1991; Saxe, Gearhart, Note, & Paduano, 1993; Valsiner, 1987). When explaining their problem-solving processes, students think about the salient features of the problem, which develops their problem-solving strategies as well as their metacognitive awareness of what they do and do not understand (Cooper, 1999). Even generating self-explanations is expected to have similar benefits, such as helping internalize principles, construct specific inference rules for solving the problem, and repair imperfect mental models (Chi, 2000; Chi & Bassock, 1989; Chi, Bassock, Lewis, Reimann, & Glaser, 1989). Giving non-elaborated help such as answers, in contrast, may not involve these cognitive processes.

Empirical findings from studies of collaboration among students support the hypothesized positive relationship between explaining and achievement (Brown & Palincsar, 1989; L.S. Fuchs, D. Fuchs, Hamlett, Phillips, Karns, & Dutka, 1997; King, 1992; Nattiv, 1994; Peterson et al., 1981; Saxe et al., 1993; Slavin, 1987; Webb, 1991; Yackel, Cobb, Wood, Wheatley, & Merkel, 1990). Similarly, giving answers without elaboration of one's thinking has been found to be negatively related, or not related, to achievement (Webb & Palincsar, 1996).

In recognition of the importance of providing students with opportunities to engage actively in interaction about the subject matter, school districts, state departments of education, national research organizations, and curriculum specialists recommend the use of peer-based learning (e.g., California State Department of Education, 1985, 1992, 2005; National Council of Teachers of Mathematics [NCTM], 1989; National Research Council, 1989, 1995; Tinzmann, Jones, Fennimore, Bakker, Fine, & Pierce, 1990). The *Professional Standards for Teaching Mathematics* (NCTM, 1991), for example, explicitly highlights the importance of students working "collaboratively to make sense of mathematics" (p. 57).

Although the potential benefits of student-directed collaboration have been widely studied, less often studied is the role of the teacher in fostering productive group collaboration. Most of the researched teacher practices concern structuring collaborative groups or tasks in certain ways, or providing certain kinds of instruction to students. Some teacher practices found to influence student interaction in peer-directed groups include instructing students in explaining skills (Fuchs et al., 1997; Gillies & Ashman, 1996, 1998; Swing & Peterson, 1982) or in giving conceptual rather than algorithmic explanations (Fuchs et al., 1997), assigning students to summarizer or listener roles (Hythecker, Dansereau, & Rocklin, 1988; O'Donnell, 1999; Yager, D.W. Johnson, & R.T. Johnson, 1985), teaching students how to ask each other specific high-level questions about the material (often called reciprocal questioning, Fantuzzo, Riggio, Connelly, & Dimeff, 1989; King, 1989, 1990, 1992, 1999); using specific metacognitive prompts to help students monitor each other's comprehension (Mevarech & Kramarski, 1997), providing students specific prompts to encourage them to give elaborated explanations, explain material in their own words, and explain why they believe their answers are correct or incorrect (Coleman, 1998; Palincsar, Anderson, & David, 1993); and using reciprocal teaching to model and explain strategies (e.g., generating questions, making predictions) that students are expected to carry out in conversations with other students (Palincsar & Brown, 1989), using instructional scaffolding (Hogan, Natasi, & Pressley, 1999), and constructing classroom norms for cooperation in groups (Yackel, Cobb, & Wood, 1991).

Rarely studied are how teachers' established instructional practices may influence how students collaborate with each other. In this paper we address the role of one aspect of teachers' instructional practices in fostering student explaining in collaborative groups: the extent to which teachers, in the context of teaching the curricular content (here, mathematics), encourage students to explain their thinking. There is a long history of teacher-dominated discourse in the classroom, in which teachers do most of the talking and students are rarely asked to share their thinking (Cazden, 2001; Cuban, 1993; Kennedy, 2004). Classroom discourse is often characterized by forms of instructional discourse described as recitation (Nystrand & Gamoran, 1991), Initiation-Response-Evaluation (I-R-E; Turner et al., 2002), or Initiation-Response-Follow-up (I-R-F; Hicks, 1995–1996; Wells, 1993) in which teachers ask students questions and evaluate their responses in a rapid-fire sequence of questions and answers with little or no wait time (Black, Harrison, Lee, Marshall, & Wiliam, 2002). Moreover, the vast majority of teacher queries consist of short-answer, low-level questions that require students to recall facts, rules, and procedures (Ai, 2002; Graesser & Person, 1994), rather than high-level questions that require students to draw inferences and synthesize ideas (Hiebert & Wearne, 1993). Even reform-minded teachers often ask questions that require students to do little more than provide correct answers (Spillane & Zeuli, 1999).

In recent years, educators and researchers have called for a different role of the teacher. The *Professional Standards for Teaching Mathematics* (NCTM, 1991) characterizes the teacher's role as "active in a different way from that in traditional classroom discourse. Instead of doing virtually all the talking, modeling, and explaining themselves, teachers must encourage and expect students to do so" (p. 36). This document highlights the importance of students clarifying and justifying their thinking, even listing specific kinds of questions that teachers might ask to stimulate student explaining, including, for example, "Does anyone else have the same answer but a different way to explain it?; Can you convince the rest of us that that makes sense?; How did you reach that conclusion?; How did you think about the problem?" (pp. 3–4), and specific practices such as regularly following "students' statements with 'Why?' or by asking them to explain" (p. 35).

The question motivating this study, and one that has rarely been examined, is whether and how teachers' instructional practices, especially the extent to which teachers do or do not encourage students to explain their thinking during classroom instruction, may influence how students interact with each other in collaborative groups.

A recent study showed that teacher-centered instructional practices may have a limiting effect on student explaining in collaborative groups. Webb, Nemer, and Ing (2006; see also Webb & Mastergeorge, 2003) examined student behavior in peer-directed groups in classrooms in which teachers implemented a large collection of activities designed to promote students' communication and help-related skills, with the goals of increasing student explaining and improving student achievement. The activities targeted help-giving skills such as providing elaborated descriptions of how to solve problems (instead of answers) and of checking for student understanding. That study focused on activities the teachers could use to prepare their students for collaborative group work and did not address, or try to change, teachers' accustomed manner of interacting with students. Teachers' instructional styles could be characterized as "teacher centered." During whole-class presentations and in much of their interactions with small groups, teachers maintained a recitation style of instruction in which they assumed most of the responsibility for setting up the steps in the problem and generally asked students simply to provide results of specific calculations that the teachers posed. Almost never in the whole class, and infrequently in visits with small groups, did teachers ask students to explain or describe how they arrived at their answers. Teacher questioning of students about their work, when it did occur, seemed intended to uncover errors that could be corrected rather than to uncover details of student thinking or misconceptions that could be addressed.

Through their behavior, then, teachers in that study modeled the role of "teacher" as active problem solver and the role of "student" as a fairly passive recipient of the teacher's instruction. In their small groups, students largely mimicked these roles, with help-givers usually giving low-level help (e.g., answers) rather than explanations, help-seekers passively receiving the help, and students rarely sharing their thinking and problem-solving strategies or probing others' thinking.

The current study, in contrast, examines teacher practices and student conversations in classrooms whose teachers were explicitly encouraged to elicit students' mathematical thinking. In particular, this study examines student behavior and teacher practices in elementary school classrooms whose teachers participated in a professional development program specifically designed to help them engage with their students in algebraic thinking around ideas of relationships between numbers and equality (Carpenter, Franke, & Levi, 2003; Jacobs, Franke, Carpenter, Levi, & Battey, 2005). Unlike the teachers in the Webb et al. (2006) study, teachers in this study received instruction and practice in posing mathematics problems designed to stimulate student thinking, asking questions to elicit student descriptions of their thinking, and setting up whole-class and small-group contexts in which students could converse with one another and with the teacher about their thinking, and in which sharing answers, ideas, and strategies was expected and encouraged.

In this report, we examine student achievement, student participation in collaborative groups, and teacher practices—and the links among them—in classrooms in which teachers received specific instruction in eliciting details of student thinking. We address the following specific questions: Does the previously demonstrated importance of student explaining for achievement hold up in these classrooms? How do student participation and teacher practices with respect to eliciting student thinking differ from those in the previous study, in which teachers did not receive such instruction and engaged in a recitation style of instruction? In classrooms with a focus on eliciting student thinking, what is the nature of the link, if any, between teacher practices and student participation in collaborative groups?

Method

Sample

Three elementary school teachers (two second-grade, one third-grade) and their students from a large urban school district in Southern California are the focus of this study. These schools serve predominantly African American and Hispanic students and are similar in terms of their academic performance, percentage of students receiving free or reduced lunch and percentage of students designated as English language learners (California

Department of Education, 2006). These teachers were part of a large-scale study focused on supporting teachers to engage with students in algebraic thinking (see Carpenter, Franke, & Levi, 2003; Jacobs et al., 2005). The teachers were from low-performing schools in a large urban district and participated in at least 1 year of on-site professional development.

Procedures

On two occasions within a 1-week period, we videotaped each teacher's class using two cameras and six audio setups. Each video camera had two audio feeds connected to flat microphones (four flat microphones in all), so that four pairs of students could be recorded simultaneously. Each flat microphone was positioned between members of a pair. Two pairs were audiotaped only. To capture the complete conversation, three microphones were used for each pair: an individual lapel microphone for each student and a flat microphone positioned between the students in the pair (each attached to a different audio recorder). The recording from the flat microphone was the primary source of the conversation in the pair; the recordings from the individual microphones were used to identify the speaker and to fill in gaps in the conversation.

Classrooms were taped as teachers taught topics related to equality and relational thinking. Teachers were asked to cover those topics but were not directed further about the particular problems to present. Teachers were also asked to incorporate "pairshare" time into the class (their accustomed practice) during which pairs of students worked together to solve and discuss problems assigned by the teacher. The structure of the class for all teachers was to introduce a problem, ask pairs to work together to solve the problem and share their thinking, and then bring the class together for selected students to share their answers and strategies with the whole class (usually at the board).

We captured all teacher-student talk during whole-class portions of the class and individual student talk during pairshare for at least 12 of the 20 students in each class. We made comprehensive transcripts of each class session consisting of verbatim records of teacher and student talk, annotated to include details of their nonverbal participation. We also collected student written work, took field notes during class sessions, administered student achievement measures (written tests and individual interviews), and surveyed teachers about their classroom practice over the course of the year.

Coding of Student and Teacher Participation

Student participation. Using transcripts of all class talk (notated to include important nonverbal interaction) and videotapes, we coded student participation during both whole-class interaction with the teacher and during pairshare for each mathematics problem according to the following categories:

1. General form of interaction among students in a pair for each problem (students were engaged in back-and-forth conversation about the mathematics; students talked about mathematics but not with or to their partner; students engaged in conversation with their partner but not about the mathematics; students did not say anything).
2. Accuracy of answer given (correct, incorrect, none).
3. Level of elaboration of mathematical talk (explanation vs. talk about the problem that did not include an explanation—e.g., answer to problem, calculations verbalized while students were trying to arrive at answer).
4. Nature of explanation given (gives correct and complete computational explanation; gives correct and complete relational thinking explanation; gives correct and nearly complete relational thinking explanation; gives ambiguous, unclear, or incomplete explanation; gives explanation for an incorrect answer; gives explanation of a faulty strategy that would lead to the incorrect answer; see Table 1 for examples).
5. Discrepancies in answers or strategies offered by members of a pair, and whether and how they were noticed, addressed, and resolved.
6. Questions students asked of each other (nature of question, nature of responses provided, and follow-up to these responses).
7. Monitoring behavior (students asking each other questions to determine their understanding of the problem or an explanation offered).

For each problem, we coded all types of participation that occurred and used dichotomous scoring for each type (e.g., a student who offered both a complete and correct computational justification for his or her answer and an ambiguous explanation was scored as offering both types of explanations). Most of the quantitative analyses use scores representing the number of problems during which a student exhibited a certain type of behavior.

Table 1

Examples of Student Explanations

Student explanation	Classroom 1	Classroom 2	Classroom 3
Correct and complete			
Computational	It will have to be 200 because 200 plus 1 equals 201. So it's the same as 1 plus 200 is the same as 201.	2 times 7 equals 14 so 3 times 2 equals 6 plus 1 equals 7.	I told him we took 5 times 3 and we put 4 plus … yeah, 5 times 3 and then we found it and it made it 15, and 15 take away, the 15 take away, um hold on. 15 take away 2 equals 13.
Relational			
Complete	I think 200 is supposed to be in the box because 200 on this side and 1 next to it equals 1 plus 200.	—[a]	I knew that 10 and 10 are the same, and I knew that 20 and 20 have to be there. So it's like a mirror. 10 and 10 are the same and 20 and 20 are the same, so they're equal.
Nearly complete	—[a]	—[a]	11 plus 2 equals 13. 10 plus 3 equals [13]. Because you have this one right here or this one right here because, because this is the greater number than this number. The greater number than this number.
Ambiguous	Say this was this one. And this one you have to like these two are the same sides. And this one is going to have to go like that one.	It just helps me, like, figure out the number.	You have the equal sign which means the same, and the little number goes to the little one and the big number goes to the big number, and so you put this to the little number too. 'Cause, look, the 2 and the 4 and we saw the times and the plus, so that's where we got the number.
Incorrect or faulty	No. It's just like 50 plus 50. They are kind of partners because they are the same but they are not (unclear).	Look. So it equals 3. I got it. It's 30. Look, it's 30, right? 30, and then you put, and then you put 74.	4. 4 plus 9 equals 5. I say it's true.

[a]Did not occur in this classroom.

Teacher participation. We coded teacher participation during whole-class interaction with the teacher and during pairshare for each mathematics problem according to the following categories: asks student(s) to give explanation; directs specific pairs to explain to each other; asks students to explain further or elaborate on what they said or did; revoices student suggestion (answer, explanation), or provides part or all of a problem-solving strategy. Table 2 gives examples for each teacher.

Table 2

Examples of Teacher Participation

Teacher participation	Teacher 1	Teacher 2	Teacher 3
Asks student(s) to explain	How do you know?	Because I don't really see any work here. I'm just a little unsure of how you came up with 345. Can you show me what you did?	No, no, no. Don't erase it. Tell me what you are doing right here.
Directs specific pair of students to explain to each other	—[a]	Now share with [Student] what you just did.	Can you explain to [Student] what you did?
Asks student to explain further or elaborate	Could you explain what numbers you are talking about?	Okay, you are using the tally strategy. Why do you have 14 tallies?	Why did you minus 10? And where did you get that 10 from?
Repeats or revoices student explanation or answer			
Student explanation	Oh, okay, I see what you saying. So the 200 and the 200 are partners. Is that what you are saying? So it doesn't matter which way. These ones are still partners. They are the same. These 200's are partners. They are still the same. So either way we do it, it's still the same on both sides.	Wow, okay. Just to clarify here. Just to clarify, it kind of seems to me like you did this in your mind? Is that kind of what you did in your mind? I'm just curious. I'm trying to clear it up here.	Okay, so you did 5 times 3 equals 15.
Student answer	You think 200.	—[a]	You still think it's false?

[a]Did not occur in this classroom.

Classwork Problems

Teachers were asked to cover equality and relational thinking on the days that we observed their classes, topics that were central to the professional development program on algebraic thinking. The following are sample problems: (1) $50 + 50 = 25 + \square + 50$, and (2) $11 + 2 = 5 + 8$ (true or false?).

Measures of Student Algebraic Reasoning

Two measures of student algebraic reasoning were used in this study. A written assessment designed to measure relational thinking was administered to all students. Four items were designed to "assess students' understanding of the equal sign, in particular, whether students held a relational view of the equal sign" (Jacobs et al., 2005). These items are referred to as the equality items because students were asked to demonstrate that the equal sign means "the same as." An example of an equality item is: $3 + 4 = \square + 5$. To answer this question, students need to know that the numbers to the left of the equal sign need to sum to the same result as the numbers to the right of the equal sign. Nine additional items were designed to assess students' abilities to identify and use number relations to simplify calculations. For example, in $889 + 118 - 118 = \square$, students could simplify this problem by recognizing that $118 - 118 = 0$.

The 12 students from each class who were audio or videotaped on the observation days were also individually interviewed. Students were asked what number they would put in the box to make certain number sentences true, for example, $13 + 18 = \square + 19$. Students were asked to describe how they solved particular problems, and both their answers and strategies were coded.

Four items addressed students' understanding of the relational nature of the equal sign, specifically the equivalence of the numerical expressions on either side of the equal sign. An example of a targeted computation item is: $889 + 118 - 118 = \square$. To answer this question, students could compute the sum of 889 and 118 and then subtract 118. Another way for students to solve this item was to recognize that $118 - 118 = 0$ so the answer is 889. Students with higher levels of relational thinking might notice this relationship between the 118s and solve this problem without needing to compute.

The analyses include three scores: (a) the score on the equality items on the written assessment, (b) the total scores on the written assessment, and (c) the total score on the individual interview.

Results

Relationship Between Student Participation and Student Achievement

This section explores the relationship between student interaction during pairshare time and student achievement. Because few students interacted with the teacher during whole-class time, the frequencies of student behavior in the whole class were small. Consequently, it was not meaningful to correlate student participation in the whole class with student achievement.

Table 3 presents correlations between categories of student participation during pairshare conversations and scores on the achievement measures. Engaging in discussion of problem-solving strategies and giving correct and complete explanations were positively related to achievement scores. The greater the number of problems during which students displayed these behaviors, the higher was their achievement. Giving no explanations was negatively related to achievement scores. The greater the number of problems during which students gave no explanation—either giving the answer only or not engaging in talk about the problem—the lower was their achievement. Giving answers (either correct or incorrect) and giving ambiguous, incomplete, or incorrect explanations were not significantly related to achievement.

Table 3

Correlations Between Student Participation During Pairshare and Achievement Scores

Student participation category[a]	Written assessment score (equality)	Written assessment score (total)	Individual interview score
General form of interaction			
Talk about problem-solving strategy	.49**	.39*	.30
Talk about answer only	-.10	-.08	.03
No talk about problem	-.39*	-.30	-.26
Gives answer	.26	.23	.12
Correct	.31	.31	.18
Incorrect	-.06	-.11	-.09
Gives explanation	.55***	.50***	.21
Correct and complete (or nearly complete)	.67***	.60***	.48**
Ambiguous, incomplete, or incorrect	-.04	-.11	-.33
Gives no explanation	-.55***	-.50**	-.21

[a]Proportion of equality and relational thinking problems in which a category occurred.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 4 presents a simplified picture of the relationship between student participation and achievement. For each problem, a student's participation was coded according to the *highest* level of participation for the problem (gives correct and complete explanation, gives ambiguous or faulty explanation, or gives no explanation). This contrasts with the previous analysis in which a student could be coded as giving explanations of different types, for example, a complete and correct explanation and an ambiguous explanation, for the same problem. As can be seen in Table 4, giving correct and complete explanations was positively correlated with achievement scores whereas giving ambiguous or faulty explanations and verbalizing mathematics work at a lower level than an explanation were both negatively correlated with achievement scores, at least for one of the two achievement measures.

Table 4

Correlations Between Student Participation During Pairshare (Highest Level of Participation on a Problem) and Achievement Scores

Highest level of student explanation on a problem during pairshare (proportion of problems)	Written Assessment Score (Equality)	Written Assessment Score (Total)	Individual Interview Score
Correct and complete explanation	.67***	.66***	.47**
Ambiguous or faulty explanation	-.17	-.15	-.44**
No explanation	-.55***	-.50***	-.21

$^{**}p < .01$. $^{***}p < .001$.

It should be noted that the correlations in Tables 3 and 4 cannot be used to draw inferences about causality. It would be preferable to compute partial correlations controlling for an antecedent measure of achievement. Although standardized test scores from the previous spring were available for the third-grade class (Teacher 2), none were available for the second-grade classes (Teachers 1 and 3) because standardized tests are not administered to first-graders in this district. Consequently, partial correlations could not be computed.

Achievement differences between classrooms. Significant differences between classrooms emerged on both measures of student achievement. As shown in Table 5, students in Teacher 3's class (Grade 2) scored the highest and students in Teacher 1's class (Grade 2) scored the lowest. The remaining sections of this report probe the student participation and teacher practices that may explain these classrooms differences in student achievement.

Table 5

Mean Student Achievement in Each Classroom

Achievement score	Classroom 1	2	3	*F*
Written assessment (Equality)	.15[a] (.28)[b]	.50[a] (.46)[b]	.75[a] (.35)[b]	8.67***
Written assessment (Total)	.16[a] (.23)[b]	.29[a] (.30)[b]	.51[a] (.19)[b]	6.60**
Individual interview	.17[a] (.30)[b]	.36[a] (.41)[b]	.38[a] (.38)[b]	4.60*

[a]Proportion of problems correct.
[b]Standard deviation.
*$p < .05$. **$p < .01$. ***$p < .001$.

Differences Between Classrooms: Student Participation During Pairshare

Significant differences between classrooms emerged for student participation. Table 6 shows differences in the general form of student interaction during pairshare across classrooms. Because teachers assigned different numbers of problems, Table 6 presents the information in terms of the proportion of problems. Students in Teacher 3's class engaged with each other around problem-solving strategies more frequently than did students in the other classes. In nearly two thirds of the problems in Teacher 3's class, on average, students engaged with each other around mathematics strategies. In the other two classes, students were most likely to talk about the answer or not talk about the problem at all.

Table 6

General Form of Interaction Between Students in Pairshare: Differences Between Classrooms

Form of interaction	Classroom[a] 1	2	3	*F*
Talk about problem-solving strategy	.27	.45	.65	6.20**
Talk about answer only	.15	.09	.15	3.00
No talk about the problem	.58	.45	.20	4.30*

[a]Mean proportion of problems with pairshare opportunities.
*$p < .05$. **$p < .01$.

Table 7

Student Explanations Verbalized During Pairshare

	Classroom[a]			
Student explanation	1	2	3	*F*
Gives explanation	.31	.32	.62	4.09*
Correct or complete	.08	.18	.48	6.94**
Ambiguous or faulty	.23	.18	.17	.96
Gives no explanation	.69	.68	.38	4.09*

[a]Mean proportion of problems.
Note. Some columns sum to more than 1.00 because some students gave both correct and incorrect explanations during discussion of a problem.
*$p < .05$. **$p < .01$.

Table 7 shows the degree to which students elaborated their thinking in each classroom. In Teacher 3's class students gave explanations on more than half of the problems, on the average, whereas students in the other classes gave explanations on about a third of the problems, on the average. Moreover, on nearly half of the problems, students in Teacher 3's class gave correct and complete explanations, whereas students in the other two classrooms gave correct and complete explanations on a small proportion of the problems.

Not only did students in Teacher 3's class give more explanations during pairshare than students in the other classes, they spent more *time* explaining than students in the other classes, as reflected in the volume of student talk during explanations. In Teacher 3's class, students who gave explanations spent an average of 193 words on their explanations during a problem, compared to an average of 117 words in Teacher 2's class, and an average of 49 words in Teacher 1's class.

Table 8 gives a simplified picture of student participation by categorizing students by whether they gave at least one correct and complete (or nearly complete) explanation on *any* problem during pairshare, whether they gave only ambiguous or faulty explanations (but never correct, complete, or nearly complete explanations), and whether they never gave an explanation on any problem. In Teacher 3's class, *every* student gave at least one correct and complete explanation. In Teacher 1's class, although most students gave at least one explanation, only a third of students gave a correct and complete explanation; half of the students only gave explanations that were ambiguous, incorrect, or incomplete. In Teacher 2's class, half of the students never gave any explanation, whether correct or incorrect; among students who did give an explanation, only a small proportion ever gave a complete and correct explanation. Differences between teachers are statistically significant, $\chi^2(2, N = 36) = 27.14, p < .001$.

Table 8

Categories of Student Participation During Pairshare

	Classroom[a]		
Category of student participation across all problems	1	2	3
Student gives at least one correct and complete (or nearly complete) explanation	.33	.18	1.00
Student gives only ambiguous or faulty explanation	.50	.27	.00
Student never gives an explanation	.17	.55	.00

[a]Proportion of students.

While the quantitative results point to important differences among classrooms in the degree to which students explained their thinking, especially whether they were able to give correct and complete explanations, closer inspection of student talk reveals further detail about the quality of the student conversations. The following excerpt from Teacher 1's class is typical of student interaction in her classroom. There is no evidence that students in this pair were talking to each other or even listening to each other. Only one person in a pair gave an explanation (S1) and it was brief and ambiguous (line 5). This student didn't clarify which numbers were "playing together" nor what he meant by the term. Nor did his partner ask him about his explanation.

Problem: 50 + 50 = 25 + □ + 50

1 S1 The second one (unclear). I don't know the first one. I don't know.

2 S2 I know the answer.

3 S1 I know the answer.

4 S2 I know the answer is 50 … it's 25.

5 S1 It's 25 for real. (unclear) And it's not 56, And not 56. 56 and not … 56 and not 56. They are playing together. They are playing together.

The next excerpt is typical of the student interaction in Teacher 2's class. As in Teacher 1's class, only one person in a pair provided an explanation. However, the explanation was longer, complete, and fairly clear. It also appears that one student (S1) was trying to explain to the other student. Although there was an attempt at conversation, the second student (S2) didn't react to the student providing the explanation, except to repeat the last few words (lines 3, 4), and the explainer did not notice her partner's incorrect answers (line 2).

Problem: $14/2 = (3 * \square) + 1$

1	S1	Three. This is … This is 3. It's a 3 plus 2 times 7 equals 14. It's a 3 because two times seven equals fourteen. So three times three equals … no wait.
2	S2	I think it's four. It equals 1.
3	S1	It's a two. Three times two equals six. Plus 1 is 7.
4	S2	Plus 1 is 7.
5	S1	Look, 2 times 7 equals 14 so we put 3 times 2 equals 6 plus 1 is 7. So right here the answer is 7.
6	S2	Let's do number two.

The excerpt below from Teacher 3's class typifies the two-way conversations that occurred during pairshare in this classroom. Students talked to each other, explained their thinking repeatedly and in detailed fashion, and explicitly referred to each others' suggestions. Moreover, they tried to apply multiple strategies for solving the problem, including a computational approach (lines 2, 4) and an approach using relational thinking (lines 4–9).

Problem 2: $11 + 2 = 10 + \square$

1	S2	Look.
2	S1	No, but I … 11 plus 2 equals 10 plus 3, huh? All I did is, um …
3	S2	Add 11 plus 2.
4	S1	I just added 11 plus 2, and then I, and then I saw it was 13, huh. So then I added 10 plus 3, and I saw it was 13 too. So I pull down a number and I put 13, huh. And then suddenly I look at they just did one up. Goes from 10, next is 11 … it goes from 2, next is 3.
5	S2	Yeah. So you know why I put the lines? It's 'cause if this is a higher number, and this is a lower number, and the next one is 2 plus 3, this is 11. 'Cause 11, this is higher, this is lower, this is higher, this is lower. So 2, if if, it doesn't care if it's switched. But 3 plus, I put this 'cause this number is lower and this number … this number is higher and this number is lower.

6 S2 And then I say that if this is higher, the next one has to be lower. And if this is lower …

7 S1 11 plus 2 equals 10 plus 3.

8 S2 And if this is lower, this has to be higher.

9 S1 I know you had told me that ’cause, ’cause I saw that too. ’Cause 11 is higher than 10, verdad, is higher than 10, y this one, this one’s lower, this one’s gotta be higher than this one. So this one’s lower and this one’s higher. And this one’s lower and this one’s higher. Get it?

Finally, differences across classrooms appeared in the extent to which students monitored each other’s work or understanding; the frequency with which students asked each other questions; and whether discrepant answers and ideas were noticed, addressed, or resolved. First, whereas students in Teacher 1’s and Teacher 2’s classes only showed one instance of monitoring behavior apiece (“Get it?”), students in Teacher 3’s class exhibited monitoring behavior nine times, including asking questions of each other (“You don’t understand it?”) and following up with explanations when a student indicated lack of understanding. Second, students in Teacher 3’s class asked each other questions more frequently than did students in the other classes (six times vs. three and one time). Students in Teacher 3’s class asked for confirmation of their strategy (“Did you all do it like I did?”) and for explanations (“How did you know it was 3?”, “Then how come you get the second…?”).

Although the incidence of discrepant answers in a pair was similar across the three classrooms, whether they were addressed and how they were resolved differed markedly across classrooms. In Teacher 1’s class, all five cases of discrepant answers went unaddressed (and in at least four cases, probably unnoticed). In Teacher 2’s class, two cases of discrepant answers went unaddressed; in three cases, students noticed the different answers and actively disagreed without resolving the disagreement (e.g., “The missing number is seven.” “No, it’s not.”). In Teacher 3’s class, students argued about and resolved their disagreements (sometimes with the help of the teacher). In one case, for example, students disagreed about whether the number sentence $4 + 9 = 5 \times 3 - 2$ was true or false. Both students voiced their reasons for their answers (e.g., the student who gave the incorrect answer “false” said “That’s 13. But this one is not. This is 15”). The student who gave the correct answer (true) explained in detail how to solve the problem, which convinced the other student, who realized his error in omitting the -2 and voiced the correct calculation (“and take away 2 is 13”).

In summary, students in Teacher 1's class tended not to engage with each other around the mathematics, which limited their opportunities to notice and resolve discrepant answers and monitor each other's work and understanding. Although most students gave at least one explanation, their explanations tended to be ambiguous or faulty. Students in Teacher 2's class also tended not to engage with each other around the mathematics, and half of them never offered an explanation. However, the students who gave explanations tended to provide correct and complete explanations. Students in Teacher 3's class more often than not did engage with each other around the mathematics. They gave the most explanations and justifications of their answers, most frequently asked questions of each other and monitored each other's understanding, and were the most likely to recognize discrepant answers and carry out active discussion to resolve disagreements.

Differences Between Classrooms: Student Participation During Whole-Class Discussions

To analyze whole-class discussions, we separated the interaction into "segments" which consisted of interaction between the teacher and a particular student. Typically, a student was called upon to share his or her answer and explain how he or she solved the problem. The teacher interacted with this student, and then called upon another student or posed another problem for the class. The analyses of whole-class discussions presented here focus on these segments.

Differences between classrooms in student participation during whole-class discussions mirror those that emerged during pairshare time. As seen in Table 9, although students in all classes gave explanations, more students gave *correct and complete* explanations during whole-class time in Teacher 2's and Teacher 3's classes than in Teacher 1's class, $\chi^2(2, N = 66) = 16.25$, $p < .001$. Moreover, students in Teacher 3's class spent more time explaining than students in the other classes, as reflected in the volume of student talk during explanations. In Teacher 1's class, students who gave explanations spent an average of 49 words in their explanations; in Teacher 2's class the average was 117 words, and in Teacher 3's class the average was 193 words. The more extensive explanations in Teacher 3's class were partly due to students' tendency to provide explanations without prompting and partly due to the teacher's frequent questioning, which encouraged students to elaborate and clarify their explanations (as described in the next section).

Table 9

Student Participation in the Whole Class

Student explanation	Classroom[a] 1	2	3
Student gives explanation	.93	1.00	1.00
Student gives correct and complete explanation	.25	.80	.71
Student gives ambiguous, incorrect, or incomplete explanation	.68	.30	.54
Student gives no explanation	.07	.00	.00

[a]Proportion of whole-class segments.
Note. Columns sum to more than 1.00 because some students gave correct and incorrect explanations in the same segment.

Differences Between Classrooms: Teacher Participation During Whole-Class Discussions[2]

Teacher participation differed across classrooms in ways that shed light on differences in student achievement and student participation. During whole-class discussions, as shown in Table 10, although all teachers asked students to explain how they solved the problem in the majority of segments, Teacher 3 asked students to provide *further* explanation in nearly all segments, whereas the other two teachers requested further explanation in about half the segments (differences between teachers are statistically significant, $\chi^2[2, N = 66] = 17.04, p < .001$). Differences between teachers also appeared in how they responded to explanations that were correct and complete versus explanations that were not (that is, explanations that were ambiguous, incomplete, or incorrect). Teachers 1 and 3 responded similarly for all explanations, whereas Teacher 2 asked for further elaboration mainly when students' initial explanations were not correct.

[2] For more in-depth discussion of how teacher participation supported students in elaborating their thinking during class discussions, see Franke et al., 2007.

Table 10

Teacher Participation During Whole Class Discussions and Pairshare

Behavior	Whole class[a]			Pairshare[b]		
	Teacher 1	Teacher 2	Teacher 3	Teacher 1	Teacher 2	Teacher 3
Asks student to explain	1.00	1.00	.96	.50	.71	.90
Requests further explanation	.46	.50	.93	.31	.06	.31
Initial explanation is correct and complete	.43	.29	.92	—[c]	—[c]	—[c]
Initial explanation is not correct/complete	.48	1.00	.93	—[c]	—[c]	—[c]

[a]Proportion of whole-class segments.
[b]Proportion of visits to pairs in which teacher engaged in this behavior.
[c] Does not apply to pairshare; teachers' requests for explanation did not occur after an initial explanation.

In the segments during which the teacher did not request further explanation from the student, teachers' practices differed little across teachers. All three teachers repeated students' answers or explanations, revoiced them, added something to them, or described a problem-solving strategy themselves.

Closer examination of teachers' practices during the whole-class segments shows the specific ways in which the teachers encouraged students to explain their thinking.

Teacher 1. Teacher 1 tended to respond only briefly to incomplete explanations that were given in conjunction with correct answers. In the following typical interchange, Teacher 1 asked a student to share how she solved the problem □ + 1 = 1 + 200. Teacher 1 repeated the student's answer but did not address or ask about her explanation (line 5). While the student indicated that putting 200 in the box made the two sides of the number sentence equal, she did not provide either a computational or a relational explanation for the equality of the two sides, leaving it unclear as to the reason *why* she thought both sides were the same (line 4).

1 T Okay [student], what do you think needs to go inside that box and why?

2 S I think 200 is supposed to be in that box.

3 T You think 200. Why do you think that?

4 S I think 200 is supposed to be in the box because 200 on this side and 1 next to it equals 1 plus 200.

5 T Okay, so does it matter where I put … So you said, 200, right?

6 S Yeah.

In some segments, Teacher 1 probed ambiguous explanations to some extent but did not push the student to give a clear and complete explanation. In the following problem, for example, students were asked to decide whether the order of the numbers on the left side of 200 + 1 = 200 + 1 influenced whether the number sentence was true (the concept of commutativity). Teacher 1 did not ask the student to explain her conception of numbers being "partners," but instead asked enough questions to obtain an explanation that she (the teacher) believed she understood, which she then revoiced more completely. Although the teacher drew a link between the student's partner idea and the equality of the number sentence, the student herself never made it clear exactly how she was linking the idea of partners to commutativity and to equality of the number sentence.

1 T Okay, who wants to share out their answers? Who wants to share out? [Student]?

2 S It doesn't matter the way you put it because it still has a partner.

3 T Oops, okay, hold on.

4 S It doesn't matter the way you put it because it still has a partner.

5 T Oh! What has a partner? What are you talking about?

6 S The numbers.

7 T Could you explain what numbers you are talking about?

8 S 200 and the ones.

9 T One more time.

10 S 200 and one and the one. The 200 and the 1.

11 T 200 and the 1 like this are partners?

12 S The 1 and the 1 are partners and the two [200's?] are partners.

13 T Oh, okay, I see what you are saying. So the 200 and the 200 are partners and the 1 and this 1 are partners. Is that what you are saying? So it doesn't matter which way. These ones are still partners. They are the same. These two

hundreds are partners. They are still the same. So either way we do it, it's still the same on both sides. True?

When students had difficulty with the problem and had trouble voicing an explanation, Teacher 1 either called another student to help or stepped in herself to direct the student to go in a certain direction with the problem. In the following problem in which students had to fill in the blank in 50 + 50 = 25 + □ + 50, the student sharing at the board obtained an incorrect answer (50) and had trouble explaining his thinking. Teacher 1 directed the student's thinking and gave him little opportunity to respond or explain. She asked bundles of questions without pausing for the student to answer (line 7). Rather than probing his thinking, Teacher 1 took control of the interchange, asking the class whether his suggested answer was correct (line 9). In the end, the student never did explain what he meant by a pattern, how he was thinking about the numbers as partners, or even how he arrived at his incorrect answer. Thus, there were few clues as to how he was thinking about the problem.

1 T Who would like to tell me what goes inside that box and you need to explain it in front of the class. [Student]? What goes inside that box?

2 S I think 50.

3 T You think 50? Go ahead and write 50 and then show us how you know that.

4 S I know because it has a pattern. So these (unclear).

5 T Doesn't need to have a pattern? What do you mean?

6 S Like it doesn't need to have a partner (unclear).

7 T Well, take a look. Karen helped us. 50 plus 50 is 100. So isn't this side 100? Can I write that? Do you agree? Okay, so how can we get to the same amount as 100 on that side? How do you know that that side is the same as 100? Can you show us by adding or by some sort of strategy to show us how you got 50?

8 S 50 plus 50 is 100.

9 T So this 50 plus this 50 you said is 100. What about the 25? Are both sides the same?

10 Class No.

11 T I see this 100 has a partner but what about the 25? It doesn't have a partner, does it? So can this answer here be 50 in the box?

12 Class No.

13 T No. Did someone else think differently?

Teacher 2. In some respects, Teacher 2's style of interacting with students was similar to that of Teacher 1. When students' explanations were correct, Teacher 2 asked few questions about them. In the following typical interchange, the student provided a correct computational explanation for the answer for the problem $14 \div 2 = (3 \times \square) + 1$. Although the student could have explained more completely, especially making explicit how the answer (two) would make the right hand side of the number sentence equal to seven (line 4), Teacher 2 did not address this issue. Unlike Teacher 1, however, Teacher 2 invited other students to share their work and thinking even when the student sharing gave a correct explanation (line 5). At her invitation, another pair volunteered their strategy and did share it.

1 T Okay [pair of students], do you want to come up and tell us how you solved number one? Remember that you need to make sure your audience is listening and that they can hear you.

2 S The answer is 2.

3 T Okay, the missing number is 2?

4 S Because 2 (unclear). Because 7 times 2 is 14 so if that equals 7 this side has to equal 7.

5 T Okay. So is there anyone who disagrees with [pair of students'] explanation on how they solved number one? Wow. Let's give them a silent round of applause. Okay. Thank you boys. Well said. Is there anyone who worked this problem out different?

Like Teacher 1, Teacher 2 probed explanations only when they were unclear. She prompted students to go in a particular direction when they had trouble explaining. In the following problem, a pair of students had difficulty explaining why they thought the answer to $14 \div 2 = (3 \times \square) + 1$ was 2. Teacher 2 did not push these students to explain their "tally" strategy or how they arrived at their answer. Instead, she provided hints for the students to help them explain how to solve the problem (lines 7, 11) and eventually invited other students to help out (line 14).

1 T Okay, tell us what you are doing right now.

2 S1 We are using the tally strategy.

3 T Okay, you are using the tally strategy. Why do you have fourteen tallies?

4 S1 14 divided by 2 is 7.

5 T Okay, so your quotient is 7.

6 S2 And there's seven groups.

7 T Okay, so how does that help you? How does knowing that 14 divided by 2 help you? I'm sorry. How does it help you to know that 14 divided by 2 is 7? How does that help you solve number one?

8 S2 Because we counted by two's.

9 T Okay.

10 S1 It's divided by 2.

11 T But how does it help you knowing that 14 divided by 2 is 7? Look at number one. Now you solved the left hand side of that problem. Now you know that the left side is seven. The answer to, the quotient, on the left hand side is 7 and how does that help you with the right hand side, with that missing number that you are looking for?

12 S2 The left side …

13 S1 7.

14 T Is there anyone out in the audience that can help out?

Teacher 3. In contrast to the other two teachers, Teacher 3 "unpacked" student work and explanations whether they were clear and correct or not. In the following example, Teacher 3 asked multiple questions of a student who gave a correct answer and explanation for the problem $11 + 2 = 10 + \square$. Through her questioning, Teacher 3 was able to uncover details of students' thinking. Furthermore, she was successful in pushing him to explain not only the computational strategy he was using (adding the numbers on the left hand side and subtracting 10 from the total) but the process he used to confirm that the answer 3 was correct (adding the two numbers on the right hand side to make sure that the total was the same as the total on the left hand side). Like Teacher 2, she invited other students to share their strategies, even though this student's answer and explanation were correct.

1 T Okay, let's lift up your papers. One, two, three. And I see a lot of people put the number 3 in here. Okay. … Okay, [student], would you like to come up?

2 S I put 11, then I put 2. And I added the 13, and I put zero here. I take away (unclear).

3 T You want to do it again? Write a little bit bigger, please.

4 S I put 11 here, put a 2 right here, then I plussed it, and it was 13. I put take away… (unclear) take away [holds fingers up]. I write 13 right here. I put right here a caret and put 13. I put here a 13. Three, 13 take away, take away (unclear) and then I minus. I minus 10. And then (unclear).

5 T Wow. Okay. This is really interesting. Okay, let's look at this. Does everybody understand how you got 11 plus 2 equals 13?

6 Class Yes.

7 T Okay. Why did you minus 10? And where did you get that 10 from?

8 S Cause on the 3 I added first … I went 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 (unclear).

9 T There. Okay, does anyone see that connection?

10 Class Yes.

11 T So he adds 11 plus 2. He adds this side together to get 13. And the way for him to find this unknown is he takes away?

12 Class 10.

13 T He takes 10 away. So 13 minus 10 equals 3, and he counted up. Okay, is there another way that someone else found that is different from his answer?

Teacher 3's interaction when a student obtained an incorrect answer was also much different from that of the other two teachers. As can be seen in the example below, Teacher 3 engaged in a lengthy process of uncovering the student's reasoning, generating a correct strategy, and making sure that the student understood the correct strategy. When the student did not know how to handle the multiple operations in the problem 4 + 9 = 5 x 3 – 2 and simply omitted the -2 to come up with the answer that the number sentence was false, Teacher 3 asked him to explain his strategy, pointed the student to the omitted - 2 (lines 9, 11), and led the student through the correct calculations until he saw the that "the equation balanced."

1 T … Okay, [Student] you thought it was false. Can you explain what you thought? Do you still think it's false now that she did it?

2 S Yeah.

3 T You still think it’s false?

4 S I thought it was false because 4 plus 9 is 13, and 5 times 3 is 15.

5 T Okay.

6 S Those two do not match.

7 T Okay, say it one more time. 4 plus 9 is 13.

8 S And 5 times 3 is 15.

9 T Is 15? You think it makes 15? You wrote 5. Write 15 on the bottom. Okay. So do you guys understand why [Student] thinks it’s false? … Because he’s looking at it like this. He says 4 plus 9 … Okay, so [Student] said 4 plus 9 is 13. Five times 3 is 15. That’s not the same number, so it’s false. Okay, I can agree with that. [Student], what about the minus two? What did you do with that?

10 S Oh!

11 T Did you see the minus two?

12 S I thought because 5 times 3 that’ll make it 15 because 5 times 3 take away 2.

13 T So it doesn’t make sense? Okay, so what could [Student 1] do? What could be the next step for [Student 1]? [Student 3], what can be the next step?

14 S2 15 take away 2 equals 13.

15 S Because I’ve never done three … 5 times 3 take away 2.

16 T This is the first time you’ve done this. Okay, so while we continue on to operate the different symbols, we can continue on with the math.

[Teacher then leads the student through the correct procedure until he obtains the correct answer and agrees that the equation balances.]

In summary, Teacher 3 showed that she valued student participation and having students explain their thinking. Teacher 3’s encouragement of student participation in the whole class is reflected in the volume of student talk when giving explanations: an average of 147 words per student who gave explanations compared with 58 and 41 words for Teacher 1 and Teacher 2, respectively. Not only did more students in Teacher 3’s class give explanations than in the other two classes, they spent more time explaining when they did so.

Differences Between Classrooms: Teacher Participation During Pairshare

Teachers differed in their patterns of interaction with pairs. Teacher 1 interacted with pairs during 18% of pairshare opportunities, compared to 35% and 40% for Teachers 2 and 3, respectively, $\chi^2(2, N = 210) = 11.13$, $p = .004$. Furthermore, as can be seen in Table 10, teachers differed markedly in their encouragement of student explaining during pairshare. Teacher 3 asked or reminded students to explain to each other or to her in most visits with pairs, Teacher 2 did so in the majority of visits, and Teacher 1 did so in half of her visits, $\chi^2(2, N = 62) = 8.74$, $p = .013$. Table 10 also shows that all three teachers tended not to ask students to elaborate further on their explanations during pairshare. Teachers 1 and 3 tended to do so more than Teacher 2, $\chi^2 (2, N = 66) = 5.20$, $p = .07$.

Teacher 1. Teacher 1 responded minimally to students' work during pairshare. When she did ask questions to prompt students to explain why they provided a specific answer, she did not push them to give a clear explanation. When students provided incorrect answers, she did not address their errors during pairshare time. She never once asked students in a pair to explain to each other.

Teacher 2. Although Teacher 2 did not ask questions of students when their answers were correct, she engaged in lengthy interactions when it appeared that students were proceeding incorrectly or did not know how to proceed. In each case, she asked questions that provided hints about solving the problem (e.g., "So remember, we always ask ourselves which of the two sides is complete. The left side or the right side?"). At the end of her interaction with every pair, she directed the students to explain to each other.

Teacher 3. In contrast to the other two teachers, Teacher 3 engaged with students both when students' work was correct and when it was incorrect or ambiguous. When students' answers were correct, she asked students to explain how they obtained their answers ("Can you explain to me what you did here?"), asked whether both students agreed on the answer and approach, prompted students to talk about their strategies with each other, and sometimes asked if students could come up with another strategy. When a student's explanation was ambiguous, she asked questions to prompt the student to clarify his or her explanations and then directed the student to explain to his or her partner.

Teacher 3 engaged in three additional behaviors to stimulate students explaining to each other, behaviors that were unique to her classroom. First, she called attention to discrepant answers in a pair and modeled how students might provide explanations to each other to resolve them. For example, when two students produced discrepant answers about whether a number sentence was true or false, she asked each student what he or she thought the answer was (lines 1, 3), and illustrated how they should proceed to address the discrepancy:

1	T	What do you think?
2	S1	I think it's true.
3	T	You think it's true? [to the other student] What do you think?
4	S2	I think it's false.
5	T	You think it's false? Okay, I want you two to talk about it. 'Cause she says it's true. So can you explain to him why you think it's true? And then you explain to her why you think it's false. You gotta watch her. No, let her speak first.

Second, she modeled how students should explain in the context of monitoring each other's work and understanding (line 5). When one student voiced an answer, she asked the other student whether he or she agreed ("Would you agree with that?") and asked whether students understood each other ("Do you understand what she's saying?") and whether they could explain to each other ("Can she understand, can she explain it to you?"). Third, she made it explicit that students should not merely accept another student's answer but should be able to explain it ("Are you just going to go with them or can you explain it too?").

In summary, during pairshare, Teacher 1 rarely gave explicit direction or encouragement of student explaining. Teacher 2, in contrast, gave general directives to each pair to explain and share. Teacher 3 encouraged student participation further by modeling *how* to share and explain in different situations, and by prompting students to take responsibility for explaining their thinking.

Conclusions

The results of this study strongly suggest a link between teacher participation and student participation. While all teachers asked students to share and to explain their thinking, they implemented these practices to different degrees and in different ways. The differences in teacher practices corresponded to differences in student participation and student achievement across the three classrooms.

Teacher 3 did the most to elicit students' explaining, by inviting students to explain and elaborate on their explanations whether their explanations were initially correct or not, and by directing students not to accept others' answers but to be able to explain why it is correct. Teacher 2 was quite explicit about directing students to share their thinking in both the pairshare and whole-class contexts, but tended to engage with students primarily when they ran into trouble (either producing an incorrect answer or strategy, or having difficulty articulating a clear explanation). In these cases, Teacher 2 prompted students to go in specific directions that would help them complete an accurate explanation. Teacher 1 was least likely to explicitly encourage students to share their thinking. In interchanges with students during pairshare, she never asked students to share their thinking with each other. During the whole class discussions, she invited alternative answers and strategies only when the student sharing at the board ran into difficulty. She tended to take control of interchanges with students, asking them bundles of questions that left students little opportunity to reflect or respond. So, compared with the other teachers, Teacher 3 gave students limited opportunities to elaborate on their explanations and, especially, to arrive at correct explanations after having given incorrect, incomplete, or ambiguous explanations.

These differences in teacher practices were reflected in student participation and achievement. Teacher 3's students explained the most, gave the most correct explanations, engaged with each other the most, and scored the highest on the achievement measures. Teacher 2's students were likely to explain correctly when they did provide explanations, and scored the second highest on the achievement measures. Teacher 1's students were least likely to engage with each other and were more likely to give ambiguous explanations or propose faulty strategies than to offer correct explanations when they did share their thinking. These students scored the lowest on the achievement measures.

These results, then, show the importance for student participation and learning of teacher practices in terms of establishing norms for student engagement, encouraging students' sharing of their thinking, and encouraging students to elaborate on their thinking.

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