An Investigation of Relationships between Seventh-Grade Students’ Beliefs and their Participation during Mathematics Discussions in Two Classrooms

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Abstract

As mathematics teachers attempt to promote classroom discourse that emphasizes reasoning about mathematical concepts and supports students’ development of mathematical autonomy, not all students will participate similarly. For the purposes of this research report, I examined how 15 seventh-grade students participated during whole-class discussions in two mathematics classrooms. Additionally, I interpreted the nature of students’ participation in relation to their beliefs about participating in whole-class discussions, extending results reported previously (Jansen, 2006) about a wider range of students’ beliefs and goals in discussion-oriented mathematics classrooms.

Students who believed mathematics discussions were threatening avoided talking about mathematics conceptually across both classrooms, yet these students participated by talking about mathematics procedurally. Additionally, students’ beliefs about appropriate behavior during mathematics class appeared to constrain whether they critiqued solutions of their classmates in both classrooms. Results suggest that coordinating analysis of students’ beliefs and participation, particularly focusing on students who participate outside of typical interaction patterns in a classroom, can provide insights for engaging more students in mathematics classroom discussions.
An Investigation of Relationships between Seventh-Grade Students’ Beliefs and their Participation during Mathematics Discussions in Two Classrooms

The purpose of this study was to determine whether there existed relationships between students’ participation during whole-class discussions and their beliefs about classroom participation. I examined the diversity among seventh-grade students’ participation within and outside of typical patterns of interaction in two mathematics classrooms. If norms of classroom discourse are mutually constituted with the students and the teacher contributing to their development (Cobb, Stephan, McClain, & Gravemeijer, 2001; Cobb, Yackel, & Wood, 1993; Yackel & Cobb, 1996), then studying a range of students’ contributions during whole-class discussions would be helpful for understanding relationships between students’ beliefs and classroom norms. This study complements research on mathematics classroom discourse that supports the development of conceptual understanding about mathematics and mathematical autonomy among students (e.g., Hufferd-Ackles, Fuson, & Sherin, 2004; Kazemi & Stipek, 2001; McClain & Cobb, 2001; McCrone, 2005) and extends this work by highlighting the students’ role in whole-class discussions about mathematics. Previously, I examined seventh-grade students’ beliefs about participation and their motivational goals, as reported during interviews, across two discussion-oriented mathematics classrooms (Jansen, 2006). In this study, I build upon previous results by analyzing these students’ participation during whole-class discussions about mathematics and investigating whether and how these seventh graders’ beliefs may have been related to their participation across two mathematics classrooms.

Theoretical Perspective
This study is a situated analysis of students’ motivation in the activity of whole-class discussion and the subject matter of mathematics. Mathematics educators have called for analyses of students’ motivation that take into account subject matter and instructional practices related to mathematics reforms (e.g., Middleton & Spanias, 1999). Analyzing students’ beliefs about engaging in a specific classroom activity and subject matter allows for extending current frameworks for analyzing students’ experiences as learners in classroom settings. For example, when the study of motivation is situated, the beliefs and goals students express may be more specific to the activity and subject matter in comparison to more general constructs such as learning goals (Ames, 1992; Dweck, 1986).

Following symbolic interactionism (Blumer, 1969, as cited in Cobb, Yackel, & Wood, 1993), I assume that beliefs have a reflexive relationship with norms of classroom discourse. Mathematics education researchers have begun to examine links between students’ beliefs and classroom norms and practices (e.g., Bowers & Nickerson, 2001; Cobb et al., 2001; Lo, Wheatley, & Smith, 1994; Stephan, Cobb, & Gravemeijer, 2003); these studies primarily emphasized the analysis of classroom norms and mathematical practices in single classrooms, complemented by analyses of students’ beliefs that focus on case studies of small numbers of students. In this study, I coordinated analyses of students’ beliefs with the analysis of social interactions by shifting the emphasis onto individual students and analyzed a larger number of cases (N = 15) of students’ participation and beliefs, with complementary analyses of typical patterns of interaction during whole-class discussions in two classrooms.
My emphasis on individual cases of students focuses on a cognitive analysis of a plurality of individuals rather than the activity of a collective (Stephan et al., 2003). A primary focus on individual students allows for mapping out the diversity of students’ perspectives in their social contexts. An examination of the diversity of students’ experiences within mathematics classroom discussions is needed to complement analyses of norms of discourse, since students may interpret the same classroom from their own unique viewpoints, even when appearing to abide by, or not actively challenge, classroom norms.

In order to account for diversity in students’ participation, I focused on their beliefs about participating. Beliefs are considered to be an ill-defined construct (Schoenfeld, 1992; Thompson, 1992). For the purpose of this study, beliefs are defined as students’ personal knowledge (Polanyi, 1958) about the process of learning mathematics that serve as the “assumptions from which individuals make decisions about the actions they will undertake” (Kloosterman, Raymond, & Emenaker, 1996, p. 39). Beliefs may also have an emotional response tied to them (Mandler, 1989). Following Speer (2005), I acknowledge that I, as a researcher, attributed beliefs about participating in mathematics classroom discussions to participants based on their interview data. The students’ talk during interviews reflected their efforts to make sense out of the social and mathematical demands of their respective classrooms, both past and present (Cobb, 1986).

Researchers usually study relationships between beliefs and actions in mathematics classrooms when they study teachers (e.g., Thompson, 1984; Speer, 2005; Skott, 2001). When researchers have studied relationships between students’ beliefs and their actions, they have examined individual students’ problem solving (e.g., Schoenfeld,
Students’ Beliefs and Participation

1989) or their work in small groups (e.g., Bills, 1999). More research is needed on relationships between students’ beliefs and actions during whole-class discussions, since discussions provide teachers with an opportunity to engage in informal assessments of their students’ thinking.

Communication and Reasoning in Mathematics Classrooms

Inviting adolescents to participate in whole-class discussions about mathematics can present unique challenges. NCTM’s (2000) *Principles and Standards for School Mathematics* briefly addresses the potential reluctance adolescents may feel about exposing their thinking during whole-class discussion. Students’ attention to social comparison information increases on entry to middle school (Stipek & MacIver, 1989) as they become more concerned with physical appearance and relationships become more important to their overall sense of well-being (Harter, 1990). Asking students to describe their thinking about mathematics publicly can exacerbate social comparisons, but all adolescents may not be equally reluctant to participate.

Middle school teachers have been observed to be more controlling than elementary school teachers at a time when students are more in need of autonomy-supportive environments for developing their academic capabilities (Eccles & Midgley, 1989). These shifts in teacher control generally occur earlier in mathematics classrooms than in other school subjects (Eccles, Wigfield, Midgley, Reuman, MacIver, & Feldlaufer, 1993). Although reforms in mathematics education in the USA advocate decreasing these controlling practices in order to increase students’ mathematical sense-making and emphasizing discourse and communication in the classroom (Lappan & Ferrini-Mundy, 1993), teachers may not implement these reforms consistently.
Students’ Opportunities for Involvement

Students’ opportunities to participate are structured by the norms of discourse in their respective classrooms. For example, students may not talk about mathematics conceptually if not encouraged to do so. US eighth graders have been asked to communicate prescribed principles and procedures over individual ideas and thinking processes more often than students in Japan or Germany (Kawanaka & Stigler, 1999). US teachers who promoted conceptual thinking in fourth- and fifth-grade classrooms developed norms for discussion which included explanations that involved mathematical arguments rather than descriptions of procedures, discussing relationships among strategies for solving problems, and using errors to reconceptualize and explore problems, while maintaining individual accountability during collaborative work and striving for consensus through mathematical argumentation (Kazemi & Stipek, 2001). Middle school teachers who managed to maintain mathematically challenging lessons chose tasks that built upon prior knowledge, used effective scaffolding, spent an appropriate amount of time on the task, modeled high-level performance, and maintained sustained pressure for explanation and meaning (Henningsen & Stein, 1997).

Students can develop mathematical autonomy in classrooms where they are asked to analyze the thinking of their classmates. In these settings, students are expected to explain and justify their reasoning, listen carefully to the thinking of their classmates during discussion, indicate when they do not understand, and explain why they believe a classmate’s contribution to be invalid (McClain & Cobb, 2001). When students’ thinking is the source of mathematical ideas, students are more likely to take responsibility for
their own learning (Hufferd-Ackles et al., 2004). However, as Hamm and Perry (2002) suggested, it may be difficult to implement discussions in this manner.

Teachers can influence not only the nature of students’ involvement, but also the frequency of their involvement and students’ motivations to participate. In upper-elementary mathematics classrooms with high-involvement from students, teachers helped negotiate understanding, transferred responsibility for learning onto students, and fostered intrinsic motivation, while in low-involvement classrooms, discourse was characterized by I-R-E sequences, emphasis on procedures, and extrinsic motivation strategies (Turner, Meyer, Cox, Logan, DiCintio, & Thomas, 1998). Students in these high-involvement classrooms reported more positive affect and experienced a match between their skills and the degree of challenge in the classroom. Additionally, sixth grade teachers who consistently encouraged students to learn, respected students, used humor, and voiced expectations that all students can learn had students with decreased avoidance behaviors in mathematics (Patrick, Turner, Meyer, & Midgley, 2003).

*Students’ Diverse Experiences with Mathematics Classroom Discussions*

Students within the same classroom experience discussions differently from one another. Lampert, Rittenhouse, and Crumbaugh (1996) described a fifth-grade class in which some students expressed discomfort with being incorrect during mathematics classroom discussions, whereas others appreciated the opportunity to hear how other students solved problems. Being corrected during classroom discussion felt, for some students, like a personal attack and affected how they felt about themselves and their classmates. These students “believed it was at least as important to maintain relationships as it was to argue mathematics” (Lampert, Rittenhouse, & Crumbaugh, 1996, p. 756).
These diverse interpretations of mathematics classroom discussions may develop due to middle school students’ experiences outside of the classroom or in previous mathematics classrooms. Lubienski (2000a, 2000b) examined the diversity of students’ experiences in one seventh-grade mathematics classroom. Her results illustrated differences along socio-economic status (SES) backgrounds such that higher-SES students participated in class discussions in order to communicate their thinking or share ideas, whereas lower-SES students were more likely to participate when they were confident they were correct, otherwise they resisted participating if they believed they might be wrong. Ridlon’s (2001) case study of a sixth grader in a problem-based mathematics classroom where students were expected to talk about their thinking revealed his resistance toward participating. The author conjectured that the student’s rural southern upbringing resulted in strong beliefs about the authority of the teacher and beliefs about mathematics involving execution of procedures without necessarily making sense of the procedures, and these beliefs conflicted with the climate of the classroom.

In Turner and Patrick’s (2004) study of two students’ involvement in mathematics classrooms in sixth and seventh grades, their changes in involvement were explained as an interaction between personal factors and opportunities in their classroom contexts, since their learning goals were consistent from one year to the next, but their involvement changed from one year to the next. However, students may adopt many different goals within the same classroom (Urdan, 2004; Wolters, 2004), so it may be possible to delineate the personal reasons students adopt for engaging in academic tasks from the climates in their mathematics classrooms.
Previously (Jansen, 2006), I learned that social goals supported middle school students’ participation during mathematics classroom discussions and motivated students to participate who might not otherwise choose to do so. In particular, students who generally avoided participating because they did not want to make a mistake in front of their peers said that they would participate if they thought it would help their peers or if they thought it was behavior expected by their teacher, and these beliefs held among students across two different classrooms. However, in Jansen (2006), I did not investigate how students with these beliefs and goals participated during classroom discourse.

Students may participate differently within the norms of discourse in the same classroom (Lubienski, 2000a, 2000b). Classroom norms cannot exclusively explain students’ involvement, yet different classrooms provide different opportunities to participate.

Methods

To examine relationships between seventh-grade students’ beliefs and participation during whole-class discussions about mathematics, I studied 15 focal students from two classrooms at the same school whose teachers used the same mathematics textbook series. The nature of discussions differed in these two classrooms. I examined whether students who held similar beliefs about participation talked similarly to one another during whole-class discussions across the two classrooms. I contrasted students’ participation between those groups of students whose beliefs differed.

The students and classrooms described in this study are those featured in a prior research report (Jansen, 2006). In the previous report, a wider range of these students’ beliefs and goals were described in greater detail, as were the relationships among their beliefs and goals. In this research report, I extend the results of my previous report by
describing these students’ behavior in their classrooms and interpreting this behavior in relation to a subset of the previously reported students’ beliefs as situated in these two classrooms.

Setting

This study took place at Two Rivers Middle School (All proper names are pseudonyms.), the single middle school (grades 6-8) in a district serving a rural community in the Midwest. The school was located in a small town, and it enrolled approximately 440 students per year. In 2001, 98.4% of the student body was White, 0.7% Native American, 0.7% Hispanic, and 0.2% Black. About 12.4% of the students received free or reduced-price lunch.

This district had used reform-oriented mathematics curricula for about 9 years at the elementary and middle grades. The middle school used *Connected Mathematics* (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2002a) as its textbook series, and the elementary school implemented *Investigations in Number, Data, and Space* (TERC, 1998). *Connected Mathematics* is a problem-based textbook series. The problems emphasize mathematical reasoning and communication and flexibility among numeric, verbal, symbolic, and graphical representations, as well as the opportunity for students to make connections among mathematical ideas and between mathematics and other disciplines. This study is not an evaluation of students’ experiences learning with this textbook series; rather, this study was set in classrooms using this textbook series because the problems in it afforded discussion about mathematics.

The mathematics problems in *Connected Mathematics* afford opportunities to engage students in classroom discourse. The Appendix includes mathematics problems
from a *Connected Mathematics* unit titled “Moving Straight Ahead” (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2002b). In this unit, students’ explore linear relationships. The problems in the Appendix are representative of *Connected Mathematics* problems in that students are asked to make connections between symbolic, graphical, and tabular representations, use real-world contexts to examine linear relationships, and explain their reasoning. Seeking connections between representations affords more discussion than being asked to write an equation for a situation in isolation from considering the situation in other representations. Additionally, when students are asked to discuss how they know a situation is a linear relationship, as seen in the Movie Problem in the Appendix and brought up in the discussion of additional problem investigations by Ms. Evans, students are provided with opportunities to justify their reasoning.

**Participants**

Two of the three seventh-grade mathematics teachers at this school volunteered to participate in this study, Ms. Carson and Ms. Evans. I invited these teachers to participate because of their experience with the mathematics textbook series and their involvement in professional development provided by the curriculum developers. Ms. Carson was a fourth year teacher who had used *Connected Mathematics* throughout her career. Ms. Evans had taught for 16 years, and she had used *Connected Mathematics* for nine of those years.

I purposefully selected (Patton, 1990) 15 focal students (7 out of 21 students in Ms. Carson’s classroom, 8 out of 24 students in Ms. Evans’s classroom) to capture diversity in gender, achievement, and participation (as observed in the first 3 weeks of school). Eight participants were female and seven were male. A range of students’
mathematical performance was included among this sample, as indicated by their third quarter course grades: four students earned an A, three had B’s, five earned C’s, three had D’s, and no participants failed third quarter. All participants were White, as were most of the students at the school.

Data Collection

The results presented in this article are part of a larger data corpus that includes videotaped classroom discussions from the fall and spring semesters, survey data from the students in these two classrooms in the fall and spring, and interviews with 15 students from both classrooms in the fall and spring; I spent approximately 100 total hours in these two mathematics classrooms at this middle school during the 2002-2003 school year for the purpose of data collection. In this article, I present results from analyses of students’ participation as captured on videotaped classroom discussion, results from analyses of interviews, including a subset of results published previously (Jansen, 2006), and analyses of relationships between students’ interview results and classroom participation results. The videotape data and interview data presented here were from late winter and early spring of 2003, which was when these two classrooms were working in the “Moving Straight Ahead” Connected Mathematics unit.

Opportunities to participate. To investigate students’ opportunities to participate in whole-class discussion, I videotaped 20 consecutive class periods, 10 in each classroom, through the use of one camera and multiple microphones, one worn by the teacher, others spread out across the classroom for capturing students’ voices. I transcribed the large group discussions that took place in these class periods. The mathematical content of these discussions focused on linear relationships. A range of
concepts and skills were discussed, including graphing a line, constructing an equation for a linear relationship, creating a table for a situation, comparing relationships, determining whether a relationship was linear, and moving between representations. These class periods were selected to capture classroom interactions after the students and teacher had been together for several months since the start of the semester, which was after some typical patterns of interaction had been established.

Students’ beliefs. As previously described in Jansen (2006), I assessed students’ beliefs about participation in an inductive, qualitative manner through interviews, following Dowson and McInerney’s (2003) assessment of middle school students’ goals in school settings. I interviewed students individually, either in the school librarian’s office or in a counseling room in the front office. Interviews lasted between 30 and 45 minutes. I asked students to discuss their views of a good mathematics teacher and the behaviors of successful mathematics students to obtain evidence about their beliefs about the process of learning mathematics (Spangler, 1992). I also asked students explicitly about classroom participation, such as, “Are you more likely to participate during class or listen? Why?”

Students’ participation. To extend results in Jansen (2006), I assessed focal students’ participation to complement the study of their beliefs for the purpose of this research report. These students’ participation was examined during four consecutive classroom discussions from the 10 videotaped class periods from each classroom. These four class periods were selected because they represented the range of typical discussions in these two classrooms in terms of time spent in discussion and classroom norms. Not all 10 class periods could be analyzed for students’ participation during discussions because
some of the days were spent exclusively on small group or individual activities. Additionally, these four days were selected because the discussions addressed the same problems from the textbook.

**Data Analysis**

*Opportunities to participate.* I developed conjectures about typical patterns of interaction in each classroom through observations across the school year. I analyzed 20 transcripts of large group discussions in the spring, 10 from each classroom, to seek confirming and disconfirming evidence for initial conjectures of typical patterns of interaction, as well as to reassess the typical patterns in each classroom, developing new conjectures. The process of seeking confirming and disconfirming evidence for these new conjectures continued for an additional cycle.

Opportunities to participate in each classroom are described in the results of this study as typical ways of interacting rather than sociomathematical norms (e.g., Yackel & Cobb, 1996). It is more conceptually consistent for the purposes of this study to refer to the description of the two classrooms as typical ways of interacting rather than normative behaviour for several reasons: (a) the classrooms are described in order to situate the results of students’ participation and are not meant to be the primary findings of the study; (b) claims about classroom norms would merit an entire study in itself and should include data from more than 10 days of class discussion; (c) the content of the typical ways of interacting are more along the lines of social norms than sociomathematical norms.

*Students’ beliefs.* Analyses of these students’ beliefs were previously reported in detail (Jansen, 2006). I analyzed interview transcripts through a constant comparative
process (Glaser & Straus, 1967), using a framework I developed for attributing beliefs to
students according to their talk during interviews. This analytic framework consisted of
three types of language cues for assessing evidence of beliefs in students’ talk: (a) modal
verbs; (b) expression of affect; and (c) repetition. Modal auxiliaries (e.g., may, might,
can, could, shall, should, will, would, ought, need), following Bills (1999), suggested
students’ expectations for how the world should operate. Affect was used as an indicators
of beliefs because beliefs are considered to be closely related to affect (McLeod, 1992).
Repetition contributed to evidence of beliefs as repetition in our talk unconsciously
indicates emphasis, similar to an orator’s use of a refrain (Tannen, 1989). The
simultaneous occurrence in students’ talk during interviews of two out of three cues from
the analytic framework, such as repetition, affect, and verb choice, enabled the
identification of themes in students’ interview responses. For a more detailed discussion
of this analytic framework, see Jansen (2006).

Students’ participation. A phase of analysis not previously reported in Jansen
(2006) involves my analysis of students’ participation. My unit of analysis for analyzing
focal students’ participation was an interaction segment. I defined an interaction segment
as either a student- or teacher-initiated series of turns in an interaction around a single
topic. Interaction segments were a useful unit for the analysis of the content of students’
talk during discussion because they encompassed both questions and responses to the
questions. I segmented all transcripts into interaction segments, and I identified themes in
the interaction segments that involved target students’ vocal participation. More than one
student may have participated in an interaction segment. Identification of themes in
interaction segments was guided by previous research on mathematics classroom
discussions that addressed the degree of conceptual talk (Kazemi & Stipek, 2001) and students’ and teachers’ authority in mathematics classrooms (Hamm & Perry, 2002; McClain & Cobb, 2001; McCrone, 2005).

*Relationships between students’ beliefs and participation.* A subset of the analyses and findings of students’ beliefs from Jansen (2006) was necessary to incorporate into this report to examine and describe relations between beliefs and their classroom participation. I employed two phases of analyses to determine whether students’ beliefs were related to their participation during whole-class discussions. I initially used an iterative, constant comparative process (Glaser & Straus, 1967), to examine whether students who held shared beliefs across classrooms participated similarly in their respective classrooms. Analyses of focal students’ beliefs and analyses of their participation were conducted independently. Then I grouped focal students by shared beliefs, and the analyses of their participation were compared with analyses of these students’ beliefs. In some cases, patterns emerged across classrooms with respect to similarities between students’ beliefs and their participation.

In the second phase of my analysis for this research report, I compared whether there were differences in relative frequencies of particular types of interaction segments between groups of students with different beliefs. I counted how many times a focus student participated during interaction segments of a particular type (e.g., conceptual talk or procedural talk) over the four-day time period. I calculated percentages for each focus student representing the percentage of the time the student participated in a particular type of interaction segment out of the total interaction segments in which the student participated over those four days. In other words, when the focus student participated,
how much of his or her participation was during a certain type of interaction segment? Then I grouped students by their beliefs to determine the mean percentage of type of interaction segment(s) for each belief group.

Results

Opportunities to Participate in Each Classroom

While these two classrooms both used the same textbook series and students had opportunities to participate in whole-class discussions in both classrooms, the nature of the opportunities to participate differed based on the typical interaction patterns in each classroom. I briefly describe the opportunities to participate in each classroom in terms of typical ways of interacting to situate the relationships between the students’ participation and their beliefs and goals in context.

INSERT TABLE 1

Students from these two classrooms did not have the same opportunities to participate with respect to frequency of participation. In Ms. Carson’s classroom, students spent more time working on seatwork than in whole-class discussion. Over 10 consecutive observation days in the spring, her class spent an average of 24.5 minutes in seatwork and an average of 15.4 minutes of whole-class discussion each day, out of a 58 minute class period, with the rest of the time spent on class business, grading homework, and introducing the day’s investigation problem. During seatwork, students were allowed to discuss problems with the other 2-3 students at their tables, but they were not required to do so. Ms. Evans’s class spent an average of 8.9 minutes daily in seatwork and 21.4 minutes in whole-class discussion. However, there was considerable variation in time spent on whole-class discussion in Ms. Evans’ class, with at least two days including over
40 minutes of discussion. In contrast, Ms. Carson’s class only had one day of a discussion that lasted 30 minutes or more over the 10-day observation period. Focal students participated in 72% of the overall interaction segments from Ms. Evans’s class and 65% of the overall interaction segments from Ms. Carson’s class, which is a similar degree of participation relative to the time spent in whole-class discussion.

There were also differential opportunities for the students to behave autonomously during whole-class discussions. Discussions in Ms. Carson’s classroom typically followed an I-R-E structure (Mehan, 1979) in which the teacher initiated a question, student(s) responded to the question, and the teacher evaluated the response(s). The discussion usually followed the sequence of the problems in the book, and the purpose of discussion was for students to check their answers from their seatwork. The students rarely shifted the topic of discussion; the teacher directed the content of the talk. Students gained the floor by calling out or by being called upon without raising their hands; participation was voluntary at times and compulsory at other times. The structure of the whole-class discussions in Ms. Evans’ class involved the teacher gathering multiple perspectives from students, then selecting and filtering the discussion toward significant mathematical ideas (Sherin, 2002). The teacher held off her evaluations of students; she instead prompted students to evaluate each others’ thinking with questions such as, “What do we think about that?” The content of discussions regularly shifted based on students’ requests, such as when a student requested to take an opportunity to revise a vocabulary definition in the middle of a series of interactions around whether or not a relationship between two quantities was linear. Students gained the floor either by raising their hands and being called upon or by calling out and claiming the floor; student
participation was voluntary, since students were rarely called upon by the teacher if their hands were not raised, but not all students who wanted to participate were able to do so, due to the number of students who were eager to participate. Ms. Carson appeared to exert more control over whole-class discussion than Ms. Evans.

Another distinct difference between these two classrooms was that humor was used frequently in Ms. Evans’s classroom. The teacher and her students told jokes and laughed together almost every class period; jokes occurred as the class period was getting started and were also interspersed throughout the whole-class discussions about mathematics. This humor may have either served as helping the students feel more comfortable with one another and willing to take risks as they seemed to know one another well personally, or it may have increased the risk of participating, as some of the humor was sarcastic, although never explicitly directed at a students’ mathematical understandings.

Although these whole-class discussions were implemented differently in both classrooms, both teachers expected their students to participate, and the content of the discussions focused on the same problems from the Connected Mathematics curriculum. At the beginning of the school year, both teachers told me they valued student participation. Although the contrasting ways of interacting in the classrooms provided different opportunities to participate and opportunities to develop unique sets of beliefs and goals in each setting, there were some similarities in how students participated across classrooms and the beliefs and goals that appeared to support the participation of the students who participated similarly to one another.

Students’ Participation across Classrooms in Relation to their Beliefs
Focus students who held a belief that participating was a part of the process to learn mathematics were more likely to talk conceptually when they participated during whole-class discussions than those who did not hold this belief. Students who believed that participating was a threatening experience and generally avoided participating during whole-class discussions if they thought they were going to be incorrect were less likely to talk conceptually about mathematics during whole-class discussions, yet they participated during talk about procedures. Additionally, students’ beliefs about the nature of appropriate behavior may have constrained their participation, since these students did not participate in critiquing their classmates thinking.

Of the 15 students I interviewed across both classrooms, eight held beliefs that participating was threatening, and seven held beliefs that participating leads to learning of mathematics; these results appear in more detail and are a subset of a larger set of results (Jansen, 2006). These results about students’ beliefs are described briefly in this report to discuss their relationship to students’ classroom participation. Of seven students from Ms. Carson’s classroom, five held beliefs that participating was threatening, and two reported beliefs that participating led to learning. In Ms. Evans’s class, three students held beliefs that participating was threatening, and five reported beliefs that participating led to learning. Fisher’s Exact test results did not show significant differences between groups of students in each classroom who held these beliefs; each classroom included a diversity of focus students’ beliefs that appeared to support or constrain their participation. Students with similar beliefs across classrooms also participated similarly in their respective classrooms.

INSERT TABLE 2
Students’ beliefs: Participating leads to learning. Seven focus students demonstrated evidence in their talk during interviews of a belief that participating during whole-class discussions helped them learn mathematics. For example, Becky said, “And when you have to do problems, don’t just sit there. You have to get into the conversation in order to actually get it yourself and make you understand it, don’t just understand it like how other kids do it.” Steve agreed with Becky, as he said, “Always try to be in the group, you know? In the big group discussion… because then you’ll understand it more, and you’ll interact with the question more.” Some students found it valuable to participate because they would get feedback on their thinking. Allison said, “I think I get it, but then I’m not sure if I have the right answer or not, so sometimes I’ll raise my hand just to see if I got it right or not. But then if I don’t, then, like, I can hear what other people are doing, too.” Focus students in both Ms. Evans’ and Ms. Carson’s classroom provided evidence in their talk that I took to indicate that they believed participating was a part of their process of learning mathematics.

Students’ beliefs: Participating is threatening. Eight focus students reported that they did not always want to participate during mathematics class due to a perceived high degree of risk associated with sharing their thinking during class discussions and potentially being incorrect in front of peers, and these beliefs constrained their participation. Tricia talked about an overall nervousness with respect to speaking in math class, “I’m kind of really shy, so I’m like super conscious about when it comes to answering in front of people. I get, like, all nervous and stuff.” Allen spoke similarly, “When I’m put on the spot, I kind of go off track. I don’t know how. Every time I’m put on the spot in front of an audience, I just panic and I can’t really think straight.” Alyssa
shared that she liked “to listen more than talking.” I asked her why that worked for her, and she said, “Because I don’t want to say the wrong answer.” Underneath feelings of being “on the spot” or being “super conscious” were fears of being publicly incorrect in front of peers. Focus students in both classrooms held beliefs about the threat of participating.

*Students’ participation: Discussing concepts.* To extend the findings of Jansen (2006), I compared the classroom talk between groups of students based on their beliefs to investigate whether they participated differently. Students may have had differential opportunities to participate across both classrooms, but even with these differences, there were some similarities among how students from each classroom participated across classrooms. The seven of the 15 focus students who believed participating helped them learn mathematics also talked about mathematics conceptually with some regularity across both classrooms; an average of 21.7% of the interaction segments they participated in contained conceptual talk. In contrast, the eight other focus students who experienced a sense of threat during the activity of participating in whole-class discussions about mathematics participated in conceptual interactions for an average of 7.2% of their interaction segments.

Also, the focus students appeared to have more opportunities to participate in conceptual talk in Ms. Evans’s classroom. More students with beliefs that participation supported learning of mathematics were in Ms. Evans’s classroom, yet students in this group from Ms. Carson’s class were still more likely to talk during conceptual talk when it occurred in Ms. Carson’s class than students who believed participating was threatening. This evidence suggests that both typical ways of interacting in classrooms
and students’ beliefs about participation contribute to students’ participation in conceptual talk about mathematics. It is interesting to note that students with similar beliefs also happened to participate similarly to one another, even in classrooms with different typical ways of interacting.

Talking about mathematics concepts did not necessarily look alike in each classroom. Ms. Carson’s students talked about concepts when they were discussing how to see the same idea in different representations, such as a table, graph, equation, or story problem context. In Ms. Evans’ class, conceptual talk about mathematics also involved applying definitions in a problem context and justifying whether or not a relationship was linear, in addition to discussing relationships among representations.

Conceptual talk in Ms. Carson’s class focused on moving flexibly between representations. This excerpt is from the walking race problem (See Appendix.). The older brother, Emile, gave the younger brother, Henri, a 45-meter head start. Emile’s walking rate was 2.5 meters per second, while Henri’s was 1 meter per second. Emile wanted Henri to win the race, but didn’t want to make the race so short that it would be obvious when Emile won. The object of the problem was to determine how long the race should be such that Henri wins in a close race. The class discussed how to see the point of intersection, or the distance and time at which the brothers would tie, in the graph and the table.

Ms. Carson: Where do I, if I have my table of time, here’s my distance, for Emile and Henri, how do I see this point of intersection on the table, because some of you did make the table, where do I see that? Tim?
Tim: When it’s on the graph, or… the table, when it says 75 and 75 on the distance [for each brother].

Ms. Carson: Yeah, so they’re both the same.

The class had just pointed out the point of intersection in the graph, and they talked about how to recognize this point in the table as well. This act of seeing a similar point, the point of intersection, across multiple representations was demonstrative of making connections across these representations.

Students in Ms. Carson’s class noticed connections between the problem context and other representations. An example was when students were interpreting how to connect points on a graph with what was happening in the walking race’s problem context.

Ms. Carson: What if I pick another point on this graph, what if I picked a point (20, 50). What does that mean, in terms of the problem here? Allison?

Allison: I think it’s 20 seconds and 50 meters…. When he’s past 20 seconds, he’s past 50 meters.

Ms. Carson: Okay, so for Emile, at 20 seconds, he’ll be at 50 meters.

The points in the graph were discussed not only in terms of their location, but also with respect to how they represented elements in the context. The interaction segment represented here addressed that the x-value was seconds and the y-value was meters, but also what happens when we looked past these points, further out on the x-axis, making connections between the functional relationship and the context. This is one of the better examples of conceptual talk from Ms. Carson’s classroom; conceptual talk occurred more rarely in comparison to the amount of procedural talk.
The two students featured in these interactions from Ms. Carson’s classroom were the two students in her class who held beliefs that participating supported their learning of mathematics. Once in a while, students who believed participating was threatening also participated in conceptual exchanges in Ms. Carson’s class, but usually Allison and Tim were the ones participating when the talk was more conceptual. There were fewer students with beliefs about participation supporting their learning in Ms. Carson’s class, and there were fewer opportunities to talk conceptually in Ms. Carson’s class in comparison to Ms. Evans’s class due to the nature of questions posed in each classroom.

Conceptual talk in Ms. Evans’s class involved talking about a linear relationship with the use of terms such as “constant rate” in light of a context. For example, students were repeatedly asked to justify whether or not they believed a relationship between two variables was linear. For example, in the walkathon problem (See Appendix.), students were examining pledge plans for walkers collecting money for a walkathon. Alana wanted to ask each sponsor for $5.00 plus 50 cents per kilometer. This was a new situation for the students with respect to linear relationships, since the graph did not start at the origin, so it presented a conundrum in that it did not have a graph exactly like the other linear relationships they had encountered. To determine whether or not it was linear, students in Ms. Evans’s class made connections between the problem context and what they already knew about linear relationships.

Ms. Evans: Steve.

Steve: Okay, thank you. See, didn’t she, didn’t someone give her a pledge for five dollars?

Ms. Evans: That’s what she’s saying, yeah.
Steve: If someone gave her a pledge for five dollars, that’s just like the zero, you know?

Steve, a student with beliefs supporting participation, justified that Alana’s plan was a linear relationship by relating the initial five dollar pledge to where you would cross the y-axis on a graph, which was at the origin in the other relationships, “just like the zero.”

Another form of conceptual talk in Ms. Evans’s class included talking about linear relationships with respect to unit rates or constant rates. Molly, another student who believed participating supported her learning, participated in talking about whether or not Alana’s plan was linear.

Ms. Evans: Okay, Molly, other thoughts.

Molly: For Alana, the reason why I thought it was, um, linear, I don’t know if it is, because a unit rate is when it’s at 1, and you really shouldn’t count the zero, because it’s really not at that, you know what I mean, because, like, one kilometer is like her unit rate, that’s [50 cents] what she gets per kilometer, so that’s why.

In another effort to relate the problem context to what they saw in the graphical representation, a practice had previously emerged in this classroom such that students agreed that they could find the unit rate represented on the graph for the y-value when the x-value was one, but this only applies when the relationship goes through the origin. When students encountered this problem context that did not go through the origin, it challenged their strategies for finding unit rates. Molly determined that Alana’s relationship was similar to the linear relationships they had encountered previously by going back to the problem context to point out the unit rate.
Ms. Evans’s classroom provided more opportunities to talk about mathematics conceptually than Ms. Carson’s class, as students were asked to justify whether a relationship was linear or not. They did so by making connections between multiple representations such as tables, graphs, equations, and problem contexts. Ms. Evans asked this question repeatedly, even when it was not included in the questions written in the textbook. In contrast, Ms. Carson focused more closely on asking the questions written in the text during whole-class discussion. Students who believed participating supported their learning spoke during conceptual exchanges across classrooms more often than students who held beliefs constraining their participation. Typical ways of interacting in each classroom were not the only factor shaping how students participated. Individual factors, such as students’ beliefs, also related to students’ participation.

*Students’ participation: Discussing procedures.* Procedural talk occurred in both classrooms and among students from both belief groups. These results demonstrate that even though students in Ms. Carson’s class may have had more opportunities to talk about mathematics procedurally, students who were unlikely to talk about mathematics conceptually still participated in procedural talk in both classrooms.

When students with beliefs that whole-class discussions were threatening spoke during Ms. Carson’s class discussions, they were more likely to participate during procedural talk. One example of procedural talk was when students described how to calculate values for the dependent variable in the walkathon problem. The following interaction is from the discussion about the walkathon pledge plans. Recall that Alana’s plan was to collect five dollars and then 50 cents per kilometer.
Ms. Carson: What about Alana [how much money would she collect after walking eight kilometers]?

Max: Nine dollars.

Ms. Carson: How did you get nine dollars?

Max: Well, she started with five dollars, and then she did 50 cents times eight, and then I got four, and I just added.

Ms. Carson: Okay, good.

Ms. Carson’s class had more opportunities to talk about procedures than Ms. Evans’s students. For example, this problem was taken directly out of the textbook, but Ms. Evans’s class did not spend time discussing it. These interactions about how to calculate values appeared to elicit more participation from students with beliefs constraining participation.

Another example of talk that was less conceptual in Ms. Carson’s class was when students answered questions about definitions of terms after they had been previously discussed, as if the teacher was checking to see if the students still remembered the definitions.

Ms. Carson: What definition do we have for the y-intercept? Hannah?

Hannah: Where the line crosses the y-axis.

These questions about recalling definitions did not occur very often in Ms. Evans’s class. Rather, students were expected to use what they knew about definitions to justify. However, these sorts of recall questions did result in participation from students with beliefs constraining participation.
The three focus students in Ms. Evans’s class who believed mathematics discussions were threatening did not speak often during Ms. Evans’s class discussions and most of the talk during discussions in her class was conceptual. One of the few times Tricia, a student with beliefs constraining participation, did participate during discussion was during one of the few times when the class discussed a calculation. Such interactions were not common in Ms. Evans’s class. In this case, the class was discussing appropriate language use when talking about a division problem.

The class was discussing a problem about two different plans for paying to go to the movies (See Appendix.). One option was to pay $4.50 per movie and the other was to pay a membership fee of $49.00 and $1.00 per movie. Students were asked to discuss how many movies they could see if they had $120.00 to spend on going to the movies. Some students talked for a while about scrolling through their tables on their graphing calculators to find the answer by looking at the independent variable values for where the dependent variable reached $120.00, until one student said he used a different calculator rather than a graphing calculator, and said that he “divided by 120.” Ms. Evans called attention to this student’s solution and spent time talking about language for expressing the division procedure, because

this type of thing comes up on the Iowa [Test of Basic Skills]… And so I’m concerned that it did not bother you to look at 4.50 divided by 120 equals 26 [writes out symbols on the overhead]. And I heard people saying, ‘Yep, that’s right. Four and a half things divided by 120, and each one is 26? That does not make sense.
The students then agreed this was “messed up” and “crazy.” Tricia offered the correct way to write the symbols, “120 divided by 4.50.” In the rare instances when procedural talk occurred in Ms. Evans’s classroom, it was connected with a purpose of making sense of the symbols. Students with beliefs constraining their participation either participated during these procedural interactions or during exchanges that did not involve mathematical talk, such as interactions about whether or not the class would have homework that night.

Talking about mathematics conceptually appears to be more challenging to middle school students than talking about mathematics procedurally, since students who associated threat with participating in whole-class discussions appeared to avoid talking about mathematics conceptually in both classrooms. Students who perceived a high degree of risk associated with participating appeared to avoid taking advantage of opportunities to participate in reasoning conceptually about mathematics, even in a classroom with many opportunities to do so.

*Students’ beliefs: Appropriate behavior.* Eight of the focus students discussed their beliefs about appropriate behavior, even though interview questions were not structured to investigate these beliefs specifically. Students’ beliefs about what counted as appropriate behavior differed between the two classrooms, while students from both classrooms held goals of behaving appropriately, as reported previously (Jansen, 2006). Out of the seven focus students from Ms. Carson’s classroom, four believed that appropriate behavior in classroom discussions involved waiting to be called upon. Hannah in Ms. Carson’s class said, “You just raise your hand, and, like, just keep your hand up until she calls on you.” Students’ behavior was regulated carefully in Ms.
Carson’s class, as indicated by Allen, when he said, “Pay attention to everything, half of it is because I don’t want to get in trouble, and then the other half is just to listen and see if there’s, like, other ways to figure out a problem.” In Ms. Evans’s class, four out of eight focus students mentioned appropriate behavior, but these students’ beliefs about the nature of appropriate behavior were more focused on rudeness of their classmates than their teacher’s expectations. For example, Becky in Ms. Evans’s class said, “I hate it when people just interrupt and interrupt and interrupt. That bugs me so much.” Marissa agreed with Becky and said,

Yeah, another thing with the class is that people disrupt, and that kind of throws you off, about train of thought, and during the problem, Ms. Evans has to stop, and it’s like, ah, you just want to yell out something. Yeah, that’s another thing, is people, I think that’s kind of, not really intimidating, but it’s just disrupting and rude. Rude.

Focus students in both classrooms discussed their beliefs about appropriate behavior, but the nature of what counted as appropriate behavior differed between classrooms.

**INSERT TABLE 3**

*Students’ participation: Critique and positioning.* Extending the analysis of students’ beliefs about appropriate behavior, results from this study demonstrate that these beliefs may have shaped their participation to some degree, as these students were less likely to participate in critiques of their classmates’ solutions. They only engaged in critique or positioning on an average of 2.9% of the interaction segments in which they participated. Their classmates who did not discuss their beliefs about appropriate behavior in the interviews were more likely to participate in critique or positioning, as an
average of 15% of their interaction segments involved this sort of participation. There were differing opportunities to critique the thinking of classmates in each classroom, and the students who discussed appropriate behavior in their interviews were about equally distributed across classrooms.

Ms. Evans encouraged her students to position themselves for and against the thinking of their classmates during discussion. She would ask students questions such as, “What do we think about that?” after a student would make a contribution to the discussion. She would not evaluate students’ thinking until several students had the opportunity to do so. The four students who held beliefs that appropriate behavior did not involve interrupting during discussion were less likely to participate during interactions when students were critiquing the solutions or ideas of their classmates.

Examples of critiquing others’ thinking occurred daily in Ms. Evans’s class. When discussing the walkathon problem, students were invited to position themselves for or against the thinking of others when students shared some equations to represent Leanne’s pledge plan. For this pledge plan, Leanne did not collect any money per kilometer, but instead asked people to donate a flat fee of $10.00 and no money per kilometer. One student, Jim, nominated an equation of \( y = 10x \) to represent this plan, and Molly provided critique of this solution.

Molly: Um, the 10, Jim’s \( y = 10x \)… wouldn’t work, because that’s saying for every kilometer that you go, you add 10 more. That’s not going to work.

Ms. Evans: So, you don’t like this one? I’m not sure that everyone at that back table is listening… [classroom management talk omitted] Molly is saying she
doesn’t like this one, say it one more time, because I’m not sure it’s all been heard.

Molly: Because, 10, it’s saying that for every kilometer I you go, you’re adding 10 more, so if you go 2, you’re gonna have 20, and it’s really only 10.

Molly was a student who held beliefs that participating was a part of the process of learning mathematics, and she did not bring up the importance of appropriate behavior in class discussions during her interviews.

When the students who held beliefs that interrupting was not appropriate behavior participated during Ms. Evans’s class, the interactions did not involve directly critiquing the thinking of classmates. For example, Becky, who was quoted above, who also held beliefs that participating led to learning of mathematics, asked for clarification about the walking race problem.

Becky: You know what I don’t get, though?

Ms. Evans: What don’t you get?

Becky: Is why, he said he wants to be close, so he knows that he didn’t cheat and he actually won.

Ms. Evans: Uh huh.

Becky: But he’s giving him a 45 second head start.

Ms. Evans: 45 meters.

Becky: I mean, 45 meters.

Ms. Evans: He was almost too nice, which all big brothers are, aren’t they?

Students: NO!

Mrs Evans: [laughs]
Becky’s contributions during this exchange illustrated her effort to grapple with the context of the problem. Her contributions represent how a student with the belief that participating leads to learning, as well as beliefs about not interrupting in order to behave appropriately, participated during mathematics class in a non-procedural manner, yet didn’t necessarily critique her classmates. Students who discussed beliefs about behaving appropriately in Ms. Evans’s class either did not directly position themselves against a classmates’ thinking or did not participate very often.

Ms. Carson’s students did not have the same opportunity to critique the thinking of classmates, as the teacher was the primary evaluator of students’ thinking in this classroom. If students did position themselves in this class, it was to support the thinking of others and agree with them. An instance of positioning in favor of the thinking of a classmate occurred when Ms. Carson’s class was talking about writing an equation to represent Alana’s pledge plan in the walkathon problem; her plan was a $5.00 donation and 50 cents per kilometer.

Ms. Carson: What about Alana? Colleen?

Colleen: Five plus point 50 K equals C.

Ms. Carson: What does that mean?

Colleen: Five plus 50 cents every kilometer. You get five dollars, times every kilometer, you get 50 cents.

Ms. Carson: Good. Anybody have a different one? Um, and if you just used different letters other than K and C, it’s still going to be the same thing.

Something other than that. Hannah?

Hannah: C equals point five K plus five.
Ms. Carson: Okay, so you just switched the equal sign, and that’s okay, it doesn’t matter. And then, point five is the same as point five zero, so you just switched…

Tim: I like it better like that.

Ms. Carson: You just switched the order…

Tim, a student with a belief that participating led to learning mathematics and who did not discuss beliefs about behaving appropriately, supported Hannah’s contribution without being called on. Students rarely spoke aloud without being called upon in this class. In this case, Tim offered unsolicited feedback on a student’s contribution, and the teacher did not respond to it, perhaps because he did not raise his hand before speaking in discussion and potentially because she was planning to evaluate the students’ contributions herself.

Students with beliefs that behaving appropriately involved listening carefully and waiting to be called upon in Ms. Carson’s class were not observed speaking without raising their hands and they did not position themselves for or against a students’ solution. However, when students who were less concerned with appropriate behavior participated in Ms. Carson’s class, sometimes they challenged the structure she placed upon discussions, such as her role as the evaluator of students’ thinking, as seen in the example above from Tim.

Providing students with the opportunity to position themselves for or against the thinking of one another could support the development of their critical thinking skills in mathematics as well as allow them to develop autonomy as mathematical thinkers (Yackel & Cobb, 1996). These opportunities occurred more often in Ms. Evans’s class than in Ms. Carson’s. However, students who discussed beliefs about appropriate
behavior were less likely to participate during opportunities to critique the thinking of others in Ms. Evans’s class. Also, some of the students positioned themselves in support of the thinking of classmates in Ms. Carson’s class, even when they were not invited to do so regularly, and these students did not discuss beliefs about behaving appropriately.

Discussion

This study illustrates how students’ beliefs about participating during mathematics class related to their participation during whole-class discussions about mathematics. These results built upon a subset of results reported previously (Jansen, 2006) in which seventh-grade students reported that the social dimension of the mathematics classroom could motivate students to participate when they might otherwise be threatened by doing so; students who believed participating was threatening said they would participate if they could help their classmates or if they would meet expectations for appropriate behavior. The results of this study extend my previous work by examining how these students participated, connecting their self-reported beliefs about participation to their classroom behavior.

In this study, students from both classrooms who believed participating during mathematics class discussions helped them learn were more likely to talk conceptually about mathematics, even though conceptual talk was different in each classroom. If students perceived participating in discussions to be threatening, they were more likely to participate during procedural talk than conceptual talk. Additionally, students who shared their beliefs about appropriate behavior during interviews were less likely to critique the thinking of classmates during whole-class discussion or position themselves for or against the thinking of their classmates. However, students’ participation in their
mathematics classrooms was not only shaped by students’ beliefs, but also by typical
different ways of interacting in each classroom, similar to results found by Turner and Patrick
(2004) in their case studies of two middle school students over two years. Investigating
similarities among beliefs and participation of students across different classrooms can
support the understanding of relationships between students’ beliefs and norms of
classroom discourse.

INSERT FIGURE 1

In this figure, I revisit a conjectured relationship between beliefs and classroom norms
(Cobb et al., 2001) and illustrate that variation in individual students’ participation is a
part of understanding this reflexivity. While a classroom may provide opportunities to
talk conceptually, not all students will engage in such talk. Students’ beliefs constrain and
support the development of classroom norms, since beliefs also constrain and support
individual students’ participation within the typical ways of interacting in a classroom.

Relationships between students’ beliefs and their actions during mathematics
class are certainly not straightforward. Even though psychological factors do not play the
only role in shaping students’ participation, they did contribute to how students
participated in these classrooms. Drawing conclusions about relationships between
beliefs and actions is unavoidably complex due to the situated nature of behavior and
reflexive relationships between beliefs and goals and students’ actions. One of the
challenges of studying relationships between students’ beliefs and their actions in the
context of large group activity is that students’ actions in a group setting are heavily
constrained by their opportunities to participate, including whether or not they are able to
get the floor. In the face of these challenges, it is worth describing observed relationships
between students’ beliefs and their actions in support of engaging more students during whole-class discussions. It may seem intuitively reasonable that students’ beliefs support their participation in their mathematics classrooms, but there is a limited body of empirical work demonstrating these relationships.

*Conjectures about the Development of Relationships between Beliefs and Participation*

Whereas this study primarily focused on psychological factors relating to students’ participation, that is, how students’ beliefs related to their behavior at one point in time, the development of these relationships can be discussed at the level of conjecture. Factors supporting the development of these relationships include, but are not limited to, the influence of their current classroom teacher, the students’ histories in previous mathematics classrooms and outside of school, and the mathematics curriculum experienced by these students, both currently and in previous years.

*Influence of current classroom teacher.* While students’ behavior was not entirely explained by the context of their current classrooms, there were some differences between the groups of focal students based on their classrooms. Typical ways of interacting in Ms. Evans’s classroom appeared to be more supportive of focus students’ mathematical reasoning with respect to conceptual talk and critiquing classmates’ thinking in contrast to Ms. Carson’s classroom. Henningsen and Stein (1997) described classroom practices that support doing mathematics at higher levels of demand, which included spending an appropriate amount of time on the task and maintaining sustained pressure for explanation and meaning. Ms. Evans’s classroom appeared to demonstrate some of these practices, as Ms. Evans’s class spent more time on discussion than Ms. Carson’s class and Ms. Evans asked students to evaluate their classmates’ thinking more
often. However, these efforts are not enough to ensure participation in conceptual talk during whole-class discussions from every student, as higher levels of demand may have been perceived as threatening by some focus students in Ms. Evans’s class.

Students’ beliefs localized to their particular classrooms focused on what counted as appropriate behavior during mathematics class. Beliefs about the nature of appropriate behavior could be revised in current or future classrooms based upon their teacher’s expectations of them or in reaction to their classmates’ behavior. Some students’ social concern for politeness in Ms. Evans’s class overrode the sociomathematical push by the teacher to position or critique. In a setting with less humor or sarcasm in which students perceive polite behavior to be in place, these students may have been less likely to avoid critique or positioning.

**Students’ histories with mathematics.** Other beliefs, such as beliefs about learning mathematics, extend beyond their experiences in their current classroom, and are an accumulation of their experiences with learning and doing mathematics both in and out of school. Yet these more general beliefs may also change due to strong contextual factors in particular classrooms (Pintrich, 2000). In this study, claims about students’ beliefs about participating in order to learn were not based solely on their talk in interviews about their current classroom experiences, as they spoke about their experiences in previous grades as well. The interview questions eliciting these data addressed learning mathematics in any context, such as what a successful student does in order to learn and what a good teacher does in order to teach effectively. Since these most of these students had been asked to talk about their thinking about mathematics since elementary school, and all but one of them (Tim) had been in *Connected Mathematics* classrooms the
previous year in sixth grade with teachers who asked them to discuss their thinking, it is not a surprise that about half of them, including Tim, believed that participating helped them learn mathematics. Also, it is possible that students who believed participation was threatening had a negative experience when they participated in a previous mathematics classroom.

This study did not explore students’ lives outside of school in relation to their beliefs or participation. Students’ histories with mathematics include both in-school and out-of-school experiences. Additional research building upon this study could examine changes in students’ talk over time, or it could incorporate theoretical perspectives that situate students’ beliefs in a larger sociocultural context, such as Lubienski’s analysis of students’ beliefs in light of economic class values (2000a, 2000b) or Ridlon’s case study of a student in a rural setting (2001).

The role of the mathematics curriculum. This study was not an evaluation of the role of Connected Mathematics in promoting particular types of talk about mathematics in whole-class discussions, but it is possible that the problems in the mathematics textbook provided opportunities for students to participate as well. The Connected Mathematics unit these students were working with during data collection for this study, “Moving Straight Ahead,” included problems that provided students with the opportunity to make connections between various representations, such as graphs, tables, equations, and story problem contexts, which would support conceptual talk about mathematics. However, the teachers’ implementations of the textbook series varied in how they engaged students in talk around these problems. Ms. Evans deviated from the list of questions in the textbook at times when she repeatedly asked the students to justify
whether relationships between variables were linear, and these questions were the ones which appeared to provide some of the opportunities to critique or position in her class. Additionally, questions in the textbook about the equation that represented a story problem context appeared to provide opportunities to critique and position in both classrooms. The mathematics curriculum can support particular ways of talking in mathematics classrooms, yet students still may engage differentially in talk around these problems.

Implications

Previous research demonstrates that students avoid challenges during discussion (Turner, Midgley, Meyer, Gheen, Anderman, Kang, & Patrick, 2002), and this study illustrates the nature of avoiding challenge while participating during mathematics classroom discussions. Students who believed participating was threatening appeared to find conceptual talk to be more threatening than procedural talk. Doyle (1983) suggested the degree of evaluation associated with a classroom task increases the risk students experience while doing academic work. Although Doyle was referring to teachers’ evaluations, it is possible that students view the opinions of their peers as informal evaluation, since students with these beliefs avoided talking about concepts in both classrooms, not just the one with a higher frequency of teacher evaluation. These students may have chosen to participate in talking about procedures over concepts because procedures are less challenging to describe.

There are alternative explanations for why students may participate in procedural talk more often than conceptual talk. For example, students’ beliefs about the nature of mathematics were not assessed in this study, but the students who participated more often
during procedural talk may have believed that the “real” talk about mathematics was during the talk about calculations and procedures due to a belief that mathematics is mostly about calculations and procedures. If students are not participating as a teacher hopes they will, it may not necessarily be due to beliefs about learning mathematics supported by motivational goals, but may also be due to general beliefs about mathematics.

So what can teachers do to involve more students in talking conceptually? This study suggests the importance of an intervention for helping students confront their beliefs about whether and how participating is helpful to their learning of mathematics for the purpose of encouraging more students to engage in conceptual talk and critical analysis of mathematical thinking during discussion. For example, teachers could explicitly discuss with their students the importance of talking about mathematics conceptually for supporting their learning. These teachers did not explicitly discuss this issue with their students, but students in these classrooms may have been introduced to this idea previously, as being expected to participate in whole-class discussion during mathematics class was not a novel experience for them during this seventh-grade year. While explicit talk in classrooms about the role of discussions in learning mathematics may make a difference, additional efforts may need to take place with students who have been expected to participate in discussions for years previously.

Additionally, teachers can promote participation for the purpose of social responsibility, such as helping their classmates, given that participants were attending to issues such as appropriate behavior. Previously, I learned that students who felt threatened by participating may still participate if they believe they can help others
(Jansen, 2006). In this study, I learned that students who felt threatened by participating were involved in class discussions during procedural talk, not during conceptual talk. If these students were participating in order to help others, then their beliefs about how to help others could have involved explaining procedures rather than concepts. Students may need to be taught how to help one another productively, such as how to offer conceptual explanations (Fuchs, Fuchs, Hamlett, Phillips, Karns, & Dutka, 1997).

Small group discussions may be less threatening than whole-class discussions. Some of the students who mentioned feeling threatened during whole-class discussions also described a reduced sense of threat when talking at their tables or with particular students. The presence of particular students in their groups, whether it was students who were intimidating or students who were not their friends, also affected their sense of threat or interest in participating in small groups. Small group discussion could help students have opportunities to learn about mathematics through talking with classmates, but may provide its own degree of complexity.

Negotiating the difference between critiquing ideas and critiquing people is also important for helping students to understand the nature of appropriate behavior in mathematics classrooms, as students who were concerned with behaving appropriately may have not considered critiquing the thinking of others to be appropriate behavior. These students may be trying to avoid making a personal attack, similarly to the fifth graders discussed by Lampert, Rittenhouse, and Crumbaugh (1996). Teachers can help students conceive of challenging their peers as appropriate behavior by educating them about how challenging one another’s thinking is a strategy for developing critical thinking and helping others learn. Indeed, this sort of behavior is very appropriate during
Students’ Beliefs and Participation

mathematics class. Students may instead think that challenging the thinking of others is unkind. If these beliefs are not confronted, they may persist, as college students avoid argumentation if it interferes with maintaining warmth in relationships (Nussbaum & Bendixen, 2003). However, these beliefs may be particularly challenging to change, since it is possible that teachers in previous grades have tried to help students think about the contract between critiquing ideas and critiquing people.

It is crucial to examine the range of students’ beliefs and ways of participating in mathematics classrooms to support the learning of all students, not only those students involved in typical patterns of interaction in their mathematics classrooms. Awareness of the diversity of participation practices of students and the beliefs that support these ways of participating can help teachers encourage more students to engage in mathematical communication and reasoning.
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Appendix

Problems Discussed (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2002b)

| Walking Race problem | Emile found out that his walking rate is 2.5 meters per second. When he gets home from school, he times his little brother Henri as Henri walks 100 meters. He figured out that Henri’s walking rate is 1 meter per second. Henri challenges Emile to a walking race. Because Emile’s walking rate is faster, Emile gives Henri a 45-meter head start. Emile knows his brother would enjoy winning the race, but he does not want to make the race so short that it is obvious his brother will win. How long should the race be so that Henri will win in a close race? Describe your strategy, and give evidence to support your answer. (p. 18) |
| Walkathon problem | Ms. Chang says that some sponsors might ask the students to suggest a pledge amount. The class wants to agree on how much they ask for. Leanne says that each sponsor should pay $10 regardless of how far a person walks. Gilberto says that $2 per kilometer would be better because it would bring in more money. Alana points out that if they ask for too much money, not as many people will want to be sponsors. She suggests that they ask each sponsor for $5 plus 50 cents per kilometer. For each pledge plan: 1. Make a table showing the amount of money a sponsor would owe if a student walked distances from 1 to 6 kilometers. 2. Graph the three pledge plans on the same coordinate axis. |
Use a different color for each plan.

3. Write an equation that can be used to calculate the amount of money a sponsor owes, given the total distance the student walks. What are the independent and dependent variables? (pp. 8 – 9)

Movie problem

A new movie theater opens in Lani’s neighborhood. The theater offers a yearly membership for which customers pay a fee of $49, after which they pay only $1 per movie. Non-members pay $4.50 per movie. Lani is trying to figure out whether to buy a membership. She writes the following equations representing the relationship between cost and the number of movies:

\[ C_M = 49 + n \]
\[ C_N = 4.5n \]

The number of movies is \( n \) and \( C_M \) is the yearly cost in dollars for a member and \( C_N \) is the yearly cost in dollars for a non-member.

A. What is the cost for a member to see 20 movies in one year? For a non-member? Explain how you found your answer.

B. Lani calculates that she has about $120 a year to spend on movies. Which plan will let her see the most movies? Explain.

C. For what number of movies is the cost of the two plans equal? What is that cost? Explain how you found the answers. How can this information be used to decide which
plan to choose?

D. Explain why the relationship between the yearly cost and the number of movies in each plan is a linear relationship.

(p. 21)
Footnotes

1The interview questions from this study have been published previously (Jansen, 2006).
Table 1

*Typical Ways of Interacting in Each Classroom*

<table>
<thead>
<tr>
<th>Ms. Carson</th>
<th>Ms. Evans</th>
</tr>
</thead>
<tbody>
<tr>
<td>• More time spent in seatwork than in whole-class discussion.</td>
<td>• More time spent in whole-class discussion than seatwork.</td>
</tr>
<tr>
<td>• I-R-E structure</td>
<td>• Deviation from I-R-E structure</td>
</tr>
<tr>
<td>• Higher frequency of teacher evaluation during whole-class discussion.</td>
<td>• Higher frequency of students evaluating each other. Less teacher evaluation.</td>
</tr>
<tr>
<td>• Participation was not always voluntary.</td>
<td>• Participation was voluntary.</td>
</tr>
<tr>
<td>• Students did not shift discussion topics.</td>
<td>• Students would shift discussion topics.</td>
</tr>
<tr>
<td>• Higher frequency of procedural talk during whole-class discussion.</td>
<td>• Use of humor.</td>
</tr>
<tr>
<td></td>
<td>• Higher frequency of conceptual talk.</td>
</tr>
</tbody>
</table>
Table 2

*Differences in Focus Students’ Beliefs by Classroom*

<table>
<thead>
<tr>
<th>Belief: Participate to learn mathematics</th>
<th>Ms. Carson</th>
<th>Ms. Evans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$N = 7$</td>
<td>$N = 8$</td>
</tr>
<tr>
<td>(Featured students)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Allison, Tim)</td>
<td></td>
<td>(Steve, Becky, Molly)</td>
</tr>
<tr>
<td>($N = 7$)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Belief: Participation is threatening</th>
<th>Ms. Carson</th>
<th>Ms. Evans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$N = 5$</td>
<td>$N = 3$</td>
</tr>
<tr>
<td>(Featured students)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Allen, Max, Hannah)</td>
<td></td>
<td>(Tricia, Alyssa)</td>
</tr>
<tr>
<td>($N = 8$)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3

*Differences in Beliefs about Appropriate Behavior by Classroom*

| Beliefs about appropriate behavior | Ms. Carson  
$N = 7$  
(Featured students) | Ms. Evans  
$N = 8$  
(Featured students) |
|-------------------------------|----------------|
| Did not discuss behaving | $N = 4$  
(Hannah, Allen) | $N = 4$  
(Marissa, Becky) |
| (N = 8) |   | |
| Did not discuss behaving | $N = 3$  
(Tim) | $N = 4$  
(Molly) |
| (N = 7) |   | |
Figure Caption

*Figure 1.* Reflexive Relationships between Psychological Factors and Participation
Student’s Psychological Factors: Beliefs, goals, attitudes, emotions

Student’s Participation
Typical ways of interacting for a student

Opportunities to Participate
Typical ways of interacting in a classroom