

Developing an Understanding of the Mediating Role of Talk in the Elementary Mathematics Classroom

Raymond Brown
GRIFFITH UNIVERSITY

Elizabeth Hirst
GRIFFITH UNIVERSITY

ABSTRACT

Classroom talk is regarded as essential in engaging and developing student understandings in the domain of mathematics. The processes of classroom talk may occur in quite different ways, ways that shape particular opportunities for learning mathematics. Little is known about how the talk produced in innovative approaches to education mediates the teaching/learning process and promotes student engagement in the practices of mathematics. Situated within a larger study that employed multiple forms of data collection to determine whether a sociocultural approach to teaching and learning could be employed by a sample of teachers to enrich the teaching and learning of mathematics, this paper examines how two teachers used talk to scaffold student learning and how this talk provided students with different opportunities for learning. In the analyses of talk produced in Year 7 classrooms we use Renshaw and Brown's (in press) discourse characterizations to make visible how different forms of talk were being used in the classrooms as thinking devices and as means to explain and generate understanding. We also employ Bakhtin's notion of 'voice' to consider whether the formats of talk used in each classroom facilitate learning in the domain of mathematics. We conclude that the intentional and reflective use of classroom talk affords students a range of opportunities to develop their mathematical thinking and to facilitate engagement with the practices of mathematics.

INTRODUCTION: THE CONTEXTS OF TEACHING AND LEARNING MATHEMATICS

In studying a representative sample of Queensland primary schools, Ainley and Perry (1994a) sought Year 7 students' views about the primary school curriculum by asking them to nominate their most and least preferred subject lesson in the school day. Thirty-five percent of respondents nominated mathematics as their least preferred lesson of the day. In an associated study, Ainley and Perry (1994b) sought Year 9 and Year 11 students' views of

their curricular experiences through the use of a Likert-type scale survey. Of the 42 Queensland secondary schools surveyed, only 54% of Year 9 students and 48% of Year 11 students agreed that learning mathematics is fun, with less than 50% of respondents from each year level agreeing that they like to do extra work in mathematics—an indicator of continuing motivation in the subject. The results of these surveys imply that many students in Queensland schools find their involvement in school mathematics to be unrewarding both in terms of their personal and civic aspirations—an implication given voice in national documents such as *A National Statement on Mathematics for Australian Schools* (Australian Education Council, 1991).

Coming to know and do school mathematics in ways that challenge students to become involved in the sociocultural practices of mathematics has been the focus of a wide range of curriculum initiatives (see for example, National Council of Teachers of Mathematics, 1991; Ontario Ministry of Education, 2004; Queensland Studies Authority, 2004). However, the idea of viewing the teaching and learning of school mathematics as occurring in classrooms, which provide students with access to the practices and ways of interacting adopted by mature mathematical communities, has gained less currency. Sentiments, echoed in reports that call for mathematics reform such as the *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, 1991), have prompted educators operating within distinct, but complementary theoretical frameworks to accept the challenge of investigating the interrelationship between students' activity, the microculture of the classroom, and the established practices of mature communities of mathematicians. For example, researchers such as Cobb (see for example, Cobb, Wood, Yackel, Nicholls, Wheatley, Tirgatti, & Perlwitz, 1991) and Lampert (see for example, Lampert, 1990) have conducted studies into classroom mathematics instruction. As a result of these studies, insights have been gained into the role that classroom talk plays in assisting students to learn grade school mathematics as members of a classroom

community of inquiry (Cobb et al., 1991) or a classroom community of discourse (Lampert, 1990). However, little research has been conducted into the mediating role played by classroom talk in the teaching and learning of mathematics and into the characteristics of classroom talk that promote student engagement in the practices of mathematics.

THEORETICAL FRAMEWORK

Through utilizing a sociocultural approach to understanding learning and development, insights may be gained into the use of talk within the mathematics classroom and into the ways that particular types of talk promote engagement in the practices of mathematics. According to sociocultural theory (Vygotsky, 1987), what takes place on the inter-psychological plane of functioning provides the basis for intra-psychological functioning. In broader terms, what takes place between students, and between the teacher and students within a classroom, may be said to have the potential to initiate students into an ever-expanding conversation—a conversation which goes beyond the walls of the classroom to engage the sociocultural practices of a mathematical community of practice (e.g., scientists, engineers, economists). What is of interest, therefore, are the constitutive features of classroom talk—features which signify that the teacher and students are participating more fully and critically in the sociocultural practices of mathematics.

According to Lampert (1998) and Cobb, McClain, & Whitenack (1997), language plays an important role in providing students with access to the sociocultural practices of mathematics. The sociocultural practices of mathematics may be said to encompass the privileged ways of knowing and doing that characterize mature communities of mathematicians and include practices such as questioning, reasoning, and justifying. From a sociocultural perspective, teachers are seen as mediators (Wertsch & Rupert, 1993) who position student learning within systems of collective practices that are culturally and historically situated. Teacher mediation in classrooms takes place in and through talk as teachers and students draw on sociocultural resources and practices to co-construct understandings (Wertsch, 1998). A sociocultural approach, therefore, emphasizes the “tension” between individuals and the mediational means (language, signs, symbols, etc.) that they have access to (Wertsch & Rupert, 1993, p. 230). A key theoretical claim is, therefore, that social interaction is fundamentally shaped by mediational means, for example, the ways classroom participants talk to each other when engaged in teaching and learning. From this perspective, classroom talk becomes a resource through which the teaching-learning mediation takes place, and, as such, it needs to be examined in order to make visible its constitu-

ent characteristics and the consequences of particular forms of talk on student learning of disciplinary knowledge. In this paper we consider the characteristics of classroom talk and the mediating role played by different formats of classroom talk on students’ participation (at the individual and group levels) in the sociocultural practices of mathematics.

Investigating the constitutive features of classroom talk requires that distinctions be made between different types of talk. Renshaw and Brown (in press), in examining the types of talk produced in classrooms where teachers were trying to engage students in the practices of a disciplinary community (e.g., science, mathematics, philosophy), identify four types of talk that teachers and students use when interacting with each other—replacement, interweaving, contextual privileging, and pastiche. With regard to mathematics teaching and learning, these formats may be described as follows.

In the *replacement format*, progress in understanding is measured by the extent to which conventional mathematical representations replace the more everyday ways of representing knowledge. Initially, there is attention and space given to the ideas, perspectives and language that students bring with them into the classroom. These provide a temporary bridge into new forms of speaking and thinking. Within this format the teacher is the expert, and it is the teacher who focuses on mathematical practices such as ‘representing’ and ‘comparing’ and on mathematical values such as ‘efficiency’ and ‘clarity’. This format is characterized by Initiation-Response-Evaluation (I-R-E) patterns of classroom interaction (see Mehan, 1979). The teacher’s role in this way of talking is to replace students’ everyday concepts with formal mathematical understandings.

Interweaving refers to a type of classroom interaction where students can populate mathematical discussions with their own purposes, for example, those relating to personal challenge, perseverance and discovery. Students weave together their mathematical ideas with the ideas of others into a form of talk that reflects their specific circumstances. Interweaving can occur at a number of levels. For example, it may occur at a level where students’ inventive ideas may be interwoven with the conventions of mathematics through employing salient elements of scientific inquiry (e.g., hypothesizing, testing, validating). It may also occur at a more personal level where students’ individual approaches to doing mathematics are interwoven with the more flexible representation systems employed by more expert mathematicians, for example, the teacher or other students. The teacher’s role in this form of interaction is to weave students’ ways of knowing and doing mathematics with those ways privileged by the discipline.

The *contextual privileging format* differs from the replacement and interweaving formats in highlighting the situational and context-specific grounds for privileging one

type of talk over another. It's not that some mathematical representations are qualitatively better in some general sense, but rather students are urged to adopt certain ways of speaking and acting because they are appropriate to the particular setting with its assumed ground rules for participation. The important aspect of the interaction between the participants is the use of context-based arguments appropriate to the mathematics of the classroom. This is a sophisticated form of classroom interaction that requires the teacher to assist students to judge the worth of an idea based on its relevance to a particular setting.

The pastiche format of classroom talk highlights multiple representations of concepts and the multivocality (Wertsch, 1991) of students' talk, that is, the social ways of interacting that characterize various group behaviors (e.g., peer, socio-economic, political, professional). The pedagogy is not primarily focused on replacing or privileging one representation of an idea with or over another, but on eliciting and communicating diverse ways of thinking and talking about concepts. Teacher participation in a pastiche format of discourse is marked by the support he/she gives to students to offer multiple representations of a concept for consideration by others. Thus, classroom talk may include various genres not typical of a mathematics class, allowing for multiple points of entry by students.

GUIDING QUESTIONS

In this paper we consider the different forms of classroom talk that occurred in two mathematics classrooms as teachers went about employing a sociocultural approach to teaching. We specifically identify two of the formats described—interweaving and contextual privileging—to examine how these two types of classroom talk make visible the collective and mediated process of learning the practices of mathematics. By presenting two 'telling' cases (Mitchell, 1984) of teachers working with their students to solve mathematical tasks, we make visible the importance of employing various types of classroom talk to maximize student access to the sociocultural practices of mathematics. Two related questions are examined in this paper:

1. What is the mediating role played by classroom talk at the individual and group levels of student participation?
2. What are the characteristics of classroom talk that promote student engagement in the practices of mathematics?

These questions are examined within a sociocultural theoretical framework, which draws on sociocultural

theorists such as James Wertsch and the work of Mikhail Bakhtin—a contemporary of Vygotsky, whose interest was primarily linguistic rather than psychological. The work of Bakhtin is of interest to the study of classroom talk as it offers an approach to the study of the interrelationships between thinking and speaking that both complements Vygotsky's writings and extends them to incorporate a concern with how 'the speaking personality' (the voice) of the active learner is located and shaped in sociocultural contexts.

VOICE: MEDIATING STUDENT INTEGRATION OF EVERYDAY AND DISCIPLINARY KNOWLEDGE

Bakhtin (1986) formulated a theory of voice that emphasized the active, situated, and functional nature of speech as it is employed by various communities within a particular society. Taking the notion of 'utterance' rather than 'word meaning' as a basic unit of communication, Bakhtin maintained that in dialogue with others, people give personal voice to utterances that are imbued with the meanings, intentions, and accents of past and present contexts of use (Bakhtin, 1981, p. 293). In this sense, Bakhtin's notion of utterance expands the basic unit of analysis to encompass a broader range of contextual issues relating to a person's perspective, belief system, intention and view of the world (Wertsch, 1991). An utterance, therefore, may be considered to be any form of spoken, written or non-verbal communication that is a link in a chain of communication—a link that reflects an interrelationship with past and future chains of communication.

Within this chain of communication, the speaking personality of the author is inherently related to the voices of others (past or present) who may either agree, disagree, augment or otherwise respond to the utterances contained within it (Bakhtin, 1986). Within the interrelationships of these chains of communication, people may align themselves within different speaking positions or voice types as they produce or respond to an utterance or a chain of utterances. Such voice types, in turn, may reflect the social ways of communicating that characterize various group behaviors (for example, professional communities, age groups, and socio-political authorities) that a person has had the opportunity and/or willingness to access. These voices are orchestrated in the classroom in particular ways, for example in discourse formats, and competence in these formats is theorized as the appropriation of voices that have audibility and status within specific social contexts (Hirst, 2003, p.174). As such, 'voice' as used in this paper, encompasses both "what" is being said, the "way" in which it is spoken, and the positioning of speakers in relation to the authority framework established within each classroom.

METHODS

The design of the comprehensive study, which arose from sociocultural methodology, was based on a “teaching experiment” (see Davydov, 1988; Schoenfeld, 2006). The “teaching experiment” is an extension of Vygotsky’s experimental-developmental method that was designed to capture the determining influence of social and cultural processes on learning and development. From this perspective, the activity of the students, the activity of the teacher/researcher, and the co-constructed activity of the classroom, interrelate at a number of levels to create the ‘life context’ of the mathematics classroom. This intervention methodology is designed to interrogate the reciprocal processes of intrapsychological and interpsychological change. A “teaching experiment” in general, therefore, involves prolonged systematic inquiry into change through engagement in collaborative cycles of analysis, design, implementation, assessment and reflection.

The comprehensive study was conducted over a one-year time frame with eight elementary school teachers (5 female and 3 male) from Years 1, 2, 4, 5, and 7 and their students. One teacher (the first author of this paper) had been using a sociocultural approach to teaching and learning mathematics in his classroom for over ten years. Of the seven other teachers involved in the study, one had been employing a sociocultural approach for 1 year and the others had mainly been employing a transmission approach, over the course of their careers, to teach mathematics. These teachers had from 1 to 20 years experience in the classroom. The teachers taught at two schools located in working and middle-class suburbs of a major city of Queensland. The schools used an outcomes based mathematics syllabus, and a mathematics textbook was mandated for use in each classroom. As the teachers mainly employed an approach to teaching mathematics that focused on demonstration and the use of the I-R-E form of classroom interaction, the study required the first author of this paper to conduct an initial period of professional development with the teachers where he co-planned and co-taught lessons to assist teachers in becoming familiar with a sociocultural approach to teaching and learning. The sociocultural approach adopted for the study was that afforded by Collective Argumentation (Brown & Renshaw, 2000).

Collective Argumentation involves the teacher and students in ways of coming to know, do and value mathematics which reflect the investigative processes and ways of interacting employed by a mathematical community. In simple terms, Collective Argumentation involves the teacher and students in small group work (2 to 5 students per group) where students are required, initially, to individually “represent” a problem by using pictures, diagrams, drawings, graphs, algorithms, numbers, etc. Stu-

dents are then required to “compare” their representations with those of other group members. This phase of individual representation and comparison provides the potential for differences in understanding of curriculum content to be exposed and examined. Subsequent talk by the students regarding the appraisal and systematization of representations is guided by the keywords—“explain”, “justify”, “agree”. Finally, moving from the small group to the classroom collective, the thinking within each group is validated for its consistency and appropriateness as it is presented to the whole class for discussion and validation.

Data Collection

The comprehensive study required each class of students and their teachers to be video/audio taped by a research assistant twice during the year when doing mathematics. Anecdotal records relating to teacher-student and student-student interactions were made on a regular basis and the teachers and those students who were able were asked to keep a reflective journal. Towards the end of the study each teacher was interviewed about their perspectives of teaching and learning mathematics. These interviews employed stimulated recall as a tool for collecting data, that is, teachers individually responded to a set of questions while watching a video of his/her classroom doing mathematics. The video served as a catalyst for reflection and discussion.

As this paper is concerned with documenting the mediating role played by classroom talk and the characteristics of talk that promote student engagement in mathematics, the first author’s Year 7 classroom and the Year 7 classroom of a teacher new to a sociocultural approach to teaching and learning mathematics were focused upon. This contrast of ‘old-timer’ with ‘new-comer’ (Lave & Wenger, 1991), mentor with mentee is consistent with the theoretical base that underpinned the study and provides an opportunity to examine some of the constraints that apply to teachers when they endeavor to bring about change in their classroom pedagogy. The year 7 classrooms (students 11-12 years of age) were located at two primary schools. In classroom A, the participants in the study were 22 students (10 male; 12 female) and the male teacher (the first author of this paper). In classroom B, the participants were 24 students (10 male; 14 female) and a female teacher (with over 10 years experience in elementary teaching). The videotaped lessons were transcribed for analysis so as to enable an investigation of the formats of classroom talk deployed. When these videotaped sessions were made, neither teacher had a formalized knowledge of the discourse formats (replacement, interweaving, contextual privileging, pastiche) as outlined previously. Transcripts were then inspected to locate teachers working with students at the individual and whole-group levels.

As little evidence was provided of the ‘new-comer’ teacher working with students at the individual level, a sequence where the teacher was interacting with students at the whole-group level was chosen for analysis. In turn, a sequence where the ‘old-timer’ teacher was working with a student at the individual level was chosen for analysis. In analyzing the transcripts and in identifying differences in students’ discussions of a mathematics task, we employed Bakhtin’s notion of ‘voice’ which acknowledges that interactions are both mediated by and mediate the social, historical and cultural context (Hirst, 2003). In our analysis, we also attempted to categorize the transcripts in terms of Renshaw and Brown’s (in press) discourse formats. Using these categories helped us to examine the complexity of the interactions that were taking place in the different classrooms by making visible how talk was being used as a thinking device and as a means to explain and to generate understanding.

In classroom A, the lesson content focused on the concept of percentage. In previous lessons the students had revised the concept of percentage and had been engaged in translating various percentage amounts into decimal and common fraction equivalents. This lesson situated these understandings within a familiar context—representing, in terms of percentage, the number of green, red, blue, and brown M&Ms (candy pieces) within a packet that contained 80 M&Ms. In classroom B, the lesson content focused on problem solving. The students had been instructed by the teacher to choose a problem from a Mathematics textbook and to solve it. The problem of interest to this paper was concerned with the additive properties of numbers.

ANALYSIS AND DISCUSSION

Classroom A—Interweaving Bernice’s Explanations with the Teacher’s Understandings

Bernice is a student who enjoys mathematics lessons and who usually turns in an above average performance on mathematics tasks. In response to the task: “What is the percentage of green, red, blue, and brown M&Ms in a packet that contains 40 green, 20 red, 16 blue, and 4 brown M&Ms”, Bernice had represented the following (see Figure 1).

FIGURE 1

Bernice’s representation of the M&M task.

Bernice’s Representation	
80 M&Ms = 100%	$80 \div 100 = 1\% = 0.8$
40 = Green = 32%	20 = Red = 16%
16 = Blue = 12.8%	14 = Brown = 11.2%
Total = 72%	

The above representation shows that Bernice understands the idea that 80 M&Ms equals 100 percent, and that she is able to use this idea to work out that one percent equals eight-tenths of an M&M. However, how Bernice uses this idea to help complete the task is not readily apparent. We enter the script where the teacher has requested an explanation from Bernice.

- Turn No.-Speaker: Script
- 01-Teacher: Which problem did you do?
- 02-Bernice: (Pointing to problem text.) Number one.
- 03-Teacher: (Looking at Bernice’s representation.) Number one.
- 04-Bernice: And I got (referring to representation) 80 M&Ms equals one hundred percent.
- 05-Teacher: So the whole box of M&Ms (points to the problem text) is a hundred percent?
- 06-Bernice: Yes.
- 07-Teacher: Okay.
- 08-Bernice: And the... eighty divided by a hundred is one percent, which is zero point eight (points to $80 \div 100 = 1\% = 0.8$ in representation).
- 09-Teacher: Why do you want to find one percent?
- 10-Bernice: So that when you times it (1%) by a hundred you get a hundred percent.
- (Plane travels overhead.)
- 11-Teacher: I didn’t hear that, can you explain it again?
- 12-Bernice: Say if you got one percent ...
- 13-Teacher: Yeah.
- 14-Bernice: (Bernice records as she speaks: $1\% \times 40 = 32\%$) And you times it (0.8) by 40 green, that gives you thirty-two percent. That would be the percentage of how many green there are ... M&Ms. And you do the same for the brown and red and blue. But it’s worked out wrong, because overall, it came to seventy-two percent, not a hundred.

In the above text, Bernice uses mathematics to work

out that one percent of the M&Ms is 0.8, but, probably because she does not label the 0.8 as part of an M&M, she is unable to see the connection between 100% equaling 80 M&Ms and one percent equaling 0.8 of an M&M. As a result, Bernice proceeds to multiply 0.8 by the various colored M&Ms and to record a percentage for each—a procedure that results in a total of 72% that Bernice recognizes as being “*wrong*” (turn 14). At this stage of the interaction, the teacher is simply trying to understand Bernice’s way of thinking about the task as is evident in the following text.

Turn No.-Speaker: Script

15-Teacher: Oh! So it’s only added up to seventy-two. So you’re saying that one M&M (records the following whilst speaking: $1\% = 0.8$ MM)...

One M&M is only point eight of a One percent, sorry, one percent... One percent is only point eight of an M&M, not even a whole M&M. That’s a bit strange isn’t it?

16-Bernice: Yes.

17-Teacher: So one percent of the contents of this box (points to problem text) is only worth point eight of an M&M. So now what did you want to find?

18-Bernice: I thought that if you timesed zero point eight by forty green M&Ms, that would...

19-Teacher: That would only give you seventy percent wouldn’t it? (Referring to Bernice’s representation of 72).

20-Bernice: It gives you thirty-two percent (referring to $1\% \times 40 = 32\%$).

21-Teacher: But I don’t have forty point eights (of an M&M), I have forty whole M&Ms don’t I?.

22-Bernice: Yes.

In coming to understand Bernice’s representation ($1\% = 0.8$), the teacher makes the important move of naming and labeling 0.8 as part of an M&M. Naming classifies and causes participants to view the named object in particular ways, with the chosen symbol emphasizing some and ignoring other characteristics of the named thing (Pimm, 1987). However, the notion that one percent can represent anything other than a whole M&M is a notion that students in this class would find “*a bit strange*” (turn 15) as they have only previously related percents to whole units. Upon establishing that “...*one percent of the contents of this box is only worth point eight of an M&M*” (turn 17), the teacher invites Bernice to continue the explanation. After some initial confusion relating to the results of one of Bernice’s operations, the teacher, working with Bernice’s ideas, draws attention to an anomaly in her reasoning. He now interweaves

his voice into the construction of a mathematical relationship, “*But I don’t have forty point eights (of an M&M), I have forty whole M&Ms don’t I?*” (turn 21). He continues:

Turn No.-Speaker: Script

23-Teacher: So if one percent is zero point eight of an M&M (Refers to record: $1\% = 0.8$), how would you find out what fifty percent was?

24-Bernice: It’s forty.

25-Teacher: I know, but how would I do it sum wise? I know that it’s forty because it’s half of eighty, but how would I do it sum wise?

26-Bernice: I don’t know.

Bernice understands this relationship and is able to relate to the problem text— benchmark understandings relating to fifty percent and to a half. However, it is not conceptual knowledge that Bernice lacks, but an understanding of how to “*find out what fifty percent was*” (turn 26)—a lack of understanding that is approached conceptually rather than procedurally by the teacher.

Turn No.-Speaker: Script

27-Teacher: Okay, well if one percent is that (points to 0.8), what would two percent be?

28-Bernice: One point six.

29-Teacher: Twice that (points to 0.8), yes, one point six. What would three percent be?

30-Bernice: Two point eight (sic).

31-Teacher: Three times that (points to 0.8), two point four. What would ten percent be?

32-Bernice: Eight.

33-Teacher: Eight M&Ms. So ten percent is worth eight M&Ms. (Records: $10\% = 8$ mm) So what’s fifty percent worth?

34-Bernice: Forty.

35-Teacher: Forty M&Ms. (Records: $50\% = 40$ mm) So how can 40 (M&Ms) be worth thirty-two percent?

36-Bernice: I don’t know.

The teacher could have recorded what 2%, 3%, 10%, and 50% of the packet of M&Ms would be using the operations of mathematics. However, he chose to interact with Bernice in such a way that integrated her way of thinking with a conventional procedure of mathematics (multiplication). The teacher is not wanting to replace Bernice’s way of doing the problem (i.e., find one percent and use this to work out the different percentages for each color M&M) with a more efficient way of doing the problem (e.g., convert

each color M&M to a fraction of the whole and multiply by 100), but to interweave Bernice’s way with the conventional understandings of mathematics. In the process, Bernice is able to reflect on what she has done and to use conceptual tools to efficiently pursue a successful solution to the task.

- Turn No.-Speaker: Script
- 37-Teacher: See, what you’ve done is, you’ve taken point eight and multiplied it by forty (refers to Bernice’s representation: $40 = 32\%$).
- 38-Bernice: (Inspects her representation.)
- 39-Teacher: You’ve multiplied M&Ms by M&Ms (points to $1\% = 0.8$; $40 = 32\%$). I wanted to say, well, that one percent is only worth point eight of an M&M.
- 40-Bernice: Oh! Okay!
- 41-Teacher: Ten percent is worth eight M&Ms. Fifty percent ..., that’s half the packet, is worth forty M&Ms. All right? Does that make sense to you?
- 42-Bernice: Yes.
- 43-Teacher: Can you take it from there?
- 44-Bernice: Yes.

In this way, Bernice can reflect on how her way of thinking about the task clashes with the logic of mathematics (“*Oh! Okay!*”) (turn 40) and on how she “*can take it from here*” (turn 43), that is, utilize her way of thinking to attain a successful solution. In the process, Bernice is provided with the opportunity to populate the mathematics with her own voice, that is, to weave together her notions with the conventional to produce a representation that reflects her specific circumstances. From a strictly mathematics perspective, Bernice has the opportunity in this interaction to learn a great deal about the language and practice of mathematics, including a strong desire to inquire and question rather than to seek closure. From a cultural perspective, this interaction between Bernice and the teacher mirrors in many ways the actual practice of the mathematics community where idiosyncratic understandings are present at various stages of the scientific work, but are obscured in the final product. In this way, the interweaving of different perspectives in classroom talk may be productive in enabling students, like Bernice, to appreciate the relevance of ‘mathematics’ in coming to ‘know’ and ‘do’ school mathematics tasks.

Classroom B—Privileging Meaning Making Over the Authority of the Text

An example of contextual privileging is provided in the following example where Jackie, Julie and Claire were presenting to their classmates a solution to a typical school mathematics problem: “When two 2 digit numbers are added

the total is 111. Subtracting the same numbers equals 18. The two numbers are _____ and _____”. The group had represented their task solution on an overhead transparency so the class could see their thinking (see Figure 2).

FIGURE 2

Group solution to the additive properties of numbers problem.

Our group’s solution		
1	$50 + 61 = 111$	$61 - 50 = 11$
2	$49 + 62 = 111$	$62 - 49 = 13$
3	$63 + 48 = 111$	$63 - 48 = 15$
4	$64 + 47 = 111$	$64 - 47 = 17$
5	$65 + 46 = 111$	$65 - 46 = 19$
We got	$64.5 + 46.5 = 111$	$64.5 - 46.5 = 18$

We join the group presentation where Claire is paraphrasing the problem for the class.

- Turn No.-Speaker: Script
- 01-Claire: When two digits are added together the total is one hundred and eleven, subtracting the same numbers equals eighteen and the two numbers are.....?
- 02-Julie: We decided to see what one hundred and eleven divided by two would equal. So we did our sum and we came up with two fifty-five point fives. In the book it said that we needed a two digit number, they (the text-book) didn’t say we couldn’t, but I didn’t think we were allowed to have decimal points. With trial and error we guessed fifty and sixty-one and that equals one hundred and eleven, but when you took them away it only equaled eleven and we needed it to equal eighteen.
- 03-Jackie: We took them (the addends) away because that would tell us how many apart they were, and we needed them to be eighteen except this one (the difference between addends) was only eleven. Our second guess was ...
- 04-Julie: Since fifty was a little too small we went down one (with the second addend) and took one up (with the first addend) and it (the sum) equaled one hundred and eleven still. Then when forty-nine was taken from sixty-two it

- only equaled thirteen and we were still off (eighteen) by five.
- 05-Jackie: Then we went up (and down) again with sixty-four plus forty-seven and that equaled one hundred and eleven, but sixty-four minus forty-seven equals seventeen, so we went up (and down) another one (time).
- 06-Teacher: It's important that people follow you. When you say you went 'up' can you say where you went up, can you just point out (on the OHT) where you went up from because that's important.
- 09-Teacher: Can you children (the class) follow where they (the group) are going up and down? Refers to the Group representation as shown on OHT (see Figure 2).
- 10-Julie: So when we did sixty-five minus forty-six it only equaled nineteen and the number we needed was in between those two (points to 64 and 65) and there was no other way we could get that number. So then we went into decimal points even though we were not allowed to.
- 11-Jackie: We went into decimal points and we got sixty-four point five plus forty-six point five equals one hundred and eleven. If you take forty-six point five from sixty-four point five you get eighteen, except in the book it said a two digit number and having a decimal point would make it a three digit number. So we think the book is wrong and it should be a three (digit) instead of a two (digit number). So we are right.
- 12-Julie: No, we are actually wrong butwe are right.
- 13-Jackie: The book is wrong and we are right.
- 14-Claire: Should we justify our answer? Are there any questions?

In explaining their solution to the class, the students relate a strategy commonly employed when doing school mathematics tasks: they make an educated guess, that is, they divide the total (111) by 2, to break it into two addends. However, this strategy yields two mixed-numbers. Dealing with mixed-numbers provides a dilemma for the students as their use seems to contradict a perceived constraint of the problem text, that is, that the addends be two digit whole numbers. The authority that the students give to the textbook is evident when they make explicit that they didn't think the use of mixed numbers was permitted (turn 02): "*In the book it said that we needed a two digit number, they (the textbook) didn't say we couldn't, but I didn't think we were allowed to have decimal points.*" Julie defines the task as a routine school task where following directions are paramount. The group chooses to defer to this authority by choosing two whole numbers that add to 111 and that are approximately half way between 0 and 111. Working from the approximate middle of 111 the students continue to use a guess and check strategy (turn 03). However, they refine the continued use of this strategy (turn 04) by incorporating 'equal addition' into their thinking, that is, by adding 1 and subtracting 1 from the whole numbers that comprised their original guess (61 and 50). As they list possibilities that sum to 111, but are proved inadequate in terms of their difference not being 18, the teacher enters the presentation and privileges clarity in the communication by requesting the students to 'point out' on their representation where they added and subtracted (turn 06). As indicated below, this privileging prompts the students to show how and why they used mixed numbers in their task solution.

- Turn No.-Speaker: Script
- 07-Jackie: Okay.
- 08-Julie: (*Referring to OHT*) One of the numbers we took from our fourth or fifth guess, sixty-four, we put another one on that and took one off forty-seven. So when we took sixty-four from forty-seven it equals seventeen.

In showing the class how they arrived at 64.5 and 46.5 as their solution, Julie and Jackie privilege reason (argument) over the perceived authority of the textbook and question the infallibility of the textbook (turn 11). However, in doing so, even though Jackie claims 'rightness'— "*So we think the book is wrong and it should be a three (digit) instead of a two (digit number). So we are right*"—Julie continues to defer to the authority of the textbook by saying that the group is wrong, but claims rightness through reason (turn 12). This deferment is not tolerated by Jackie who forthrightly proclaims that "*the book is wrong*" and privileges the group's reasoning over the infallibility of the text. This privileging is endorsed by Claire, who, participating for the first time in the presentation of the group's thinking, is prepared to further justify the group solution and to answer questions from the class (turn 14).

A different voice to the one commonly found in school mathematics classrooms (see Schoenfeld, 1988) is deployed by the students in the above extract. Drawing upon a developing understanding of a mathematical voice that privileges reason ("*Should we justify our answer*") and accountability ("*Are there any questions?*") over deferment to the authority of the text ("*No we are actually wrong butwe are right*"), the group demonstrates a particu-

lar sensitivity to the context of their interactions with the class. This context goes beyond the hypothetical ‘expert’ audience offered by textbooks and instead focuses on the mathematical adequacy of the group’s presentation to their peers. The important aspect of the interaction between the participants is not their use of mixed-number representations per se, but the use of context-based arguments in defense of mixed-number representations. The group, particularly Julie (turn 12), isn’t dismissing the authority of the text as being irrelevant, but as being inappropriate in the present mathematical context of this particular task. This is a sophisticated stance that entails judging the worth of an idea on its relevance to a particular setting. This privileging of reason and accountability continues in the following extract.

- | Turn No.-Speaker: | Script |
|-------------------|--|
| 15-Student: | Did you only guess five times? |
| 16-Claire: | We guessed a bit more but it was unnecessary. |
| 17-Jackie: | Because we wanted to show how we went up (adding and subtracting from the addends). |
| 18-Julie: | Some of them (the addends) were really UP, really far off whack—there was like thirty something between the numbers (the two addends). |
| 19-Teacher: | So, do you think it (the task according to the textbook) can be done? |
| 20-Jackie: | This way yes. From what the book says it couldn’t be done. |
| 21-Student: | (<i>To the teacher</i>) do you think it could be done? |
| 22-Teacher: | I don’t know. |
| 23-Julie: | (<i>To the teacher</i>) you did think it could be done before, but we proved you wrong. |
| 24-Teacher: | (<i>To the class</i>) Any other questions for them? Who thinks it can be done?
(<i>To the group</i>) Talk about how you worked it out with even and uneven numbers. |

Moving beyond questions related to ‘guessing’ (turn 15), the group focuses on showing their thinking to the class (turns 17, 18). However they are brought back to the authority of the text by the teacher (turn 19). The utterance—“*So do you think it (the task according to the textbook) can be done?*”—implies a reluctance by the teacher to dismiss the authority of the textbook on the basis of one group’s response to the task. This reluctance is perhaps spurred on by Julie when she states that the group proved not only the textbook wrong but also the teacher, (turn 23) and is reinforced when the teacher makes a general appeal to the class (turn 24)—“*Who thinks it can be done?*” In the face of the teach-

er’s apparent reluctance to go against the authority of the text, the group maintains the argument that the text is wrong. This contradiction of the teacher’s voice is not an act of defiance by the group, but an example of a mathematical virtue which Polya (1954) refers to as ‘wise restraint,’ where a mathematical justification is not changed wantonly, without serious examination. In this way, the group’s mathematical voice begins to resonate with the confidence of the knower, struggling to represent what they know about the nature of mathematical textbooks and to connect that to the knowledge of the teacher— an emotionally risky resonance, but necessary to taking up an authoritative voice (Kutz, 1990). The teacher provides the group with a further opportunity to display their authority by directing them to “*talk about how you worked it out with even and uneven numbers*” (turn 24).

In response to the teacher’s direction, Julie goes on to explain the group’s thinking about the task by using the addition and subtraction of single digit numbers to convey the group’s reasoning. In the process, not only does the group deploy an authoritative stance, but they use that authority to take members of the class beyond using the ‘guess and check’ strategy on textbook tasks towards using a form of algebraic thinking akin to that used by mathematicians when solving simultaneous equations. Magnanimous in their triumph over the erroneous textbook, Julie provides possible sources of that error and contextualizes the textbook to the delivery of a curriculum, where the use of whole numbers to solve tasks is a more frequent occurrence than the use of mixed-numbers. In this way, Julie provides a face-saving strategy for the textbook authors and perhaps the teacher. This strategy is taken up by the teacher as she shifts ownership of the textbook to the class—“*they (the group) tried to argue against your textbook*”—and assigns the textbook to an inferior status within the life of the classroom—“*that’s why we don’t use those kind of textbooks*”.

CONCLUSION

In this paper we considered the mediating role played by classroom talk on students’ participation in the sociocultural practices of mathematics. As illustrated in the analysis relating to classroom A, the teacher promoted the kind of classroom talk that facilitated the weaving together of a student’s personal understanding with conventional mathematical understandings. Within this hybrid form of meaning making, the teacher shared his expertise—his authority—with Bernice, giving value to her way of knowing and doing the M&M task. In this way, Bernice was encouraged to adaptively deploy the teacher’s expertise to extend her own approach to solving the problem. In terms of Renshaw and Brown’s (in press) discourse formats, the interaction be-

tween the teacher and Bernice is an example of engagement in the 'interweaving' format of classroom talk—a form of talk that seems particularly suited to engaging students in the sociocultural practices of mathematics at the individual level. It is not that the teacher in classroom A deliberately set about to engage Bernice in a particular format of classroom talk—at this stage of the study, he (the first author) had no formalized understanding of such categories of talk. What he did have, however, was a commitment to a sociocultural approach to the teaching and learning of mathematics based on the Vygotskian (1987) understanding that the interweaving of personal understandings and conventionalized or schooled understandings is basic to the teaching/learning process.

However, at the whole-group level, the interaction between teachers and students needs to go beyond privileging the personal to privileging the social, that is, privileging certain ways of speaking and thinking. As illustrated in classroom B, in the interactions between the group (Jackie, Julie and Claire) and the other members of the class, certain ways of speaking and thinking about the task, for example, using mixed-numbers, are chosen over other possibilities on the grounds of appropriateness to a specific set of ground rules for participation. For these students, it was inappropriate to use whole numbers to solve the problem even though an authoritative text seemed to demand it. Instead, the group was able to engage a process of discursive negotiation whereby consensus could be reached through reason and proof rather than through submission to the teacher's or textbook's authority. This type of discursive negotiation is an example of 'contextual privileging'. The 'contextual privileging' format of classroom talk provides a view of development as situated and contextualized. Certain ways of speaking and thinking are appropriate and privileged in particular contexts, rather than simply correct or incorrect, true or false. This format of classroom talk promotes the view that 'learners' occupy a range of roles in the process of coming to know—novice, expert, conformer, resistor, listener, speaker, etc., and that the specific circumstances in which an activity is situated by the participants has a determining influence on the degree to which a person engages with the practices associated with the social world in which that activity is lived.

In terms of the larger study referred to in this paper,

our findings suggest that teachers can employ the pedagogical strategies associated with a sociocultural approach to the teaching and learning of mathematics as long as they are supported within their school communities and provided with on-going assistance (Brown & Renshaw, 2006). However, the level of efficacy of talk engaged by teachers and students within these classrooms varies. It has been our observation that, for some teachers, perceived accountability requirements to standardized, external testing regimes rarely permit the sharing of authority within the classroom in a manner that promotes engagement in classroom talk beyond the 'replacement' format. For others, perceived restraints of the school timetable demand that they almost exclusively employ the 'contextual privileging' format at the whole class level and seldom engage the 'interweaving' format at the individual level. Analyses of videotapes of classroom talk suggest that transforming teacher practice in the mathematics classroom requires the teacher to learn how to balance the complex interaction between content knowledge, pedagogical techniques, and contextual understandings with the institutional requirements of schooling. How teachers may be assisted to address this balance is the focus of our future research.

However, the analysis of classroom talk in this paper provides a sense that the characteristics of classroom talk that productively engage students in the practices of mathematics are those that assist students in making sense of the mathematics being presented to them and that assist students in linking their ideas to the conventions of mathematics rather than to teacher and/or textbook evaluations of students' answers. Nevertheless, teachers need to be flexible in their use of classroom talk as a tool for promoting participation and development in the learning process. They need to have a variety of discourse formats at their disposal and be able to use them intentionally, to achieve specific learning goals, not only the 'interweaving' and 'contextual privileging' formats that we have illustrated, but also the 'replacement' and 'pastiche' formats described earlier. Our aim in this paper has not been to advocate for one or other format of classroom talk, but rather to insist that teachers need to be reflective and critical users of classroom talk, and understand their role in orchestrating talk so as to improve the quality of the learning opportunities offered to students in the mathematics classroom.

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Correspondence regarding this article should be addressed to Raymond Brown or Elizabeth Hirst at School of Education & Professional Studies (Gold Coast), Gold Coast Campus, Griffith University, QLD 4222, Australia. Email should be sent to ray.brown@griffith.edu.au or e.hirst@griffith.edu.au