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CHAPTER FIVE

Participation of Students in Content-Learning Classroom Discourse: A Study of Two Grade 8 Mathematics Classes in Singapore

INTRODUCTION

Cazden (2001) pointed out that, in contexts such as schools, "one person, the teacher, is responsible for controlling all the talk that occurs while class is officially in session – controlling not just negatively, as a traffic officer does to avoid collisions, but also positively, to enhance the purposes of education" (p. 2). Herbel-Eisenmann (2009) noted the two main functions of talk and distinguished between discourse for content-learning purposes and discourse for social purposes. According to Herbel-Eisenmann, discourse for content-learning brings the learning of content to the foreground and moves the social control to the background. For example, a statement like "This function is a linear function" is mainly about the mathematics being studied (p. 30), while a statement like "Please put your notebooks away so we can go to lunch" serves more strongly a social control function (p. 30) and therefore may be classified as discourse for social purposes.

As part of the Learner's Perspective Study (LPS) in Singapore, we have studied sequences of lessons of three competent mathematics teachers at the eighth grade level. In our past studies (Kaur, 2008, 2009; Seah, Kaur, & Low, 2006) we have found that the lessons of these teachers were

- guided by very specific instructional objectives;
- the examples used during whole class demonstration were carefully selected and systematically varied in complexity from low to high;
- teachers actively monitored student's understanding during seatwork, as they moved from desk to desk guiding those with difficulties and selecting appropriate student work for subsequent whole class review and discussion; and
- reinforced student understanding of knowledge expounded during whole class demonstration by detailed review of student work done in class or as homework.

In addition, in the classes of these teachers, students attached importance to their teacher's explanations which were simple and logical; demonstration of mathematical procedures – showing them the "method" or concrete representation of a concept with the use of a manipulative; introduction of new knowledge – knowledge they were being exposed to for the first time; instructions that guided them in their work and the use of real-life examples that helped them appreciate the use of mathematics in life. As part of seatwork, students attached importance to

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individual work during class time that provided practice and an opportunity to check for own understanding; group work during which they experienced teamwork spirit and peer support and the material (mainly in print form) given by the teacher to engage them in practice of concepts and skills they had learned. As part of review and feedback they attached importance to review of prior knowledge which helped to bridge past knowledge with the present and also in the construction of new concepts using past knowledge; student presentations which resulted in the use of student work to highlight mistakes and demonstrate alternative approaches and feedback given to students individually during class time and also through grading of written assignments.

However, our past studies have not focussed on the nature of the classroom discourse in the classes of these teachers. Therefore to understand the nature of discourse for content-learning purposes a study of teacher-student discourse in the classrooms that is specific to public talk and content-learning purpose was undertaken and reported in this chapter.

In this chapter we provide an analysis of the data for two teachers in the study which is guided by the following research questions: During content-learning classroom discourse

(i) how often do students get an opportunity to engage in public talk?
(ii) what are the characteristics of teacher-student public talk?
(iii) what are the teachers' orientation of discourse (conceptual or calculational)?
(iv) do students initiate any public talk with their teachers or peers? If so, what was the purpose of the talk?

LITERATURE REVIEW

Showing and telling or explaining the ideas to be learned is often the predominant approach to teaching mathematics in most Singapore classrooms both in the primary and secondary schools. This does not appear to be unique to Singapore schools as showing and telling appear to have been traditional practices in classroom teachings for generations and continues to dominate classroom practice (Pimm, 1987). In classrooms where this takes place the discourse is teacher dominated and teachers may engage students in some dialogue according to their planned 'next step'. However, often little use is made of students' contribution as the nature of contribution sought from the students is not for deliberation but rather confirmation of their understanding.

Alternatives to showing and telling involve reviewing and restructuring (Anghileri, 2006) which aid development of students' own understanding of mathematics. Reviewing relates to interactions where the teacher encourages experiences to focus students' attention on pertinent aspects of the mathematics involved and restructuring involves teachers making adaptations to modify the experiences and bring the mathematics involved closer to students' existing understanding (p. 41). This approach would facilitate a student-centred discourse where the teacher would take on the role of a facilitator. Some significant actions in such classrooms would be students' explaining their thinking with justifications, teachers asking probing questions and rephrasing students' talk and negotiating meanings.

To study teacher-student oral interactions specifically during content-learning in mathematics lessons is certainly significant but the challenges to do so are also present. Stein (2007) noted that classroom discourse can be difficult to assess as classroom talk is dynamic. Hufferd-Ackles, Fuson, and Sherin (2004) created a framework to describe and evaluate the process a class goes through when discourse is introduced. The framework depicts growth in a math-talk learning community in two ways: the movement through four developmental levels from a traditional mathematics classroom in Level 0 to a classroom embracing meaningful collaborative math-talk in Level 3 and the growth that occurred within each of the four components from Level 0 to Level 3 which include (a) questioning, (b) explaining mathematical thinking, (c) source of mathematical ideas, and (d) responsibility for learning (see Hufferd-Ackles, Fuson, & Sherin, 2004, pp. 88-90). Stein (2007) adapted the framework, shown in Table 1, to assess discourse level in a mathematics classroom.

Table 1. Levels of discourse in a mathematics classroom

Levels	*Characteristics of Discourse*
0	The teacher asks questions and affirms the accuracy of answers or introduces and explains mathematical ideas. Students listen and give short answers to the teacher's questions.
1	The teacher asks students direct questions about their thinking while other students listen. The teacher explains student strategies, filling in any gaps before continuing to present mathematical ideas. The teacher may ask one student to help another by showing how to do a problem.
2	The teacher asks open-ended questions to elicit student thinking and asks students to comment on one another's work. Students answer the questions posed to them and voluntarily provide additional information about their thinking.
3	The teacher facilitated the discussion by encouraging students to ask questions of one another to clarify ideas. Ideas from the community build on one another as students thoroughly explain their thinking and listen to the explanations of others.

According to Thompson, Philip, Thompson, and Boyd (1994) there are two contrasting teachers' orientations in classroom discourse. They characterised them as conceptual orientation and calculational orientation. A teacher with conceptual orientation is one whose actions are driven by the ways of thinking he/she wants the students to develop, students' engagement that can orient the students' attention in productive ways and insistence that students are intellectually engaged in tasks and activities. The questions conceptually orientated teachers often ask their students that allow them to view their arithmetic in a noncalculational context like the following:

– "What are you trying to find when you do this calculation?
– "What did this calculation give you?"

A teacher with calculational orientation is driven by the application of calculations and procedures for "getting answers". Although such teachers do not focus only on computational procedures, there is a tendency to speak exclusively in numbers and numerical operations language. They place emphasis on identifying and performing procedures and have an inclination to remediate students' difficulties with calculational procedures often disregarding the context in which the difficulties might have occurred. The questions a teacher with calculational orientation often asks his/her students tend to be computational in nature such as:

– "Why did you subtract 7 from 38?"
– "How come you multiplied 7 and 3?"

Both orientation of teachers' classroom discourse involve the teacher posing questions to which students' answer.

Alternatively, students too may pose questions to their teachers and peers. These questions serve different functions such as confirmation of an expectation, resolution of an unexpected puzzle, and filling a recognised knowledge gap (Biddulph & Osborne, 1982). The type of questions shows the gap or discrepancy in the students' knowledge or a desire to extend knowledge in some direction. Besides helping students learn, student questioning can also guide teachers in their work. Questions also reveal much about the quality of students' thinking and conceptual understanding (White & Gunstone, 1992).

Wong and Quek (2010) in their work on promoting student questions in mathematics lessons claim that most lessons are about one or more of the following four aspects: meaning, method, reasoning, and application. As such a variety of questions may be asked by students about each of these aspects. An example is as follows:

> Suppose the teacher has just spent about 15 minutes explaining congruency between triangles ABC and XYZ. The students may not have understood certain parts of the explanation and want to ask some focussed questions. Below are some possible questions.
>
> *Meaning*: How is the symbol "≡" different from the equal sign?
> *Method*: Do we have to strictly keep to the order of pairing A with X, B with Y, and C with Z?
> *Reasoning*: Why do congruent triangles have the same area?
> *Application*: When do people use congruent triangles in real life?
>
> (Wong & Quek, 2010, p. 2)

Analysing questions posed by students during content-learning discourse may shed light on what the student is focussing on during the learning of mathematics.

METHODOLOGY

Method

The study in Singapore adopted the research design as set out in the Learner's Perspective Study (LPS) (Clarke, 2006). A total of three mathematics teachers recognised for their locally-defined 'teaching competence' participated in the study. These teachers are from a pool of teachers deemed as "experienced and competent", where experience was a measure of the number of years they have taught mathematics in secondary schools and competency was a composite measure of their students' performance at examinations and their performance in class in the eyes of their students. The teachers were nominated by their respective school leaders and the LPS research team in Singapore followed up on the nominations and interviewed the teachers. A strict requirement for participation in the study was that the teacher had to teach the way she / he did all the time, i.e. no special preparation was allowed. Three teachers who met the requirements agreed to participate in the study.

Video-records of 13 consecutive lessons (three during the familiarisation stage and ten as part of the study) for each teacher were collected using three cameras. The Teacher camera captured the teacher's actions and talk during the lesson. The Student camera focused on a group of two students, known as the "focus group" and captured their actions and talk during the lesson. Each group of pupils was only videotaped once. The Whole Class camera captured the whole class in action. The source of data for this chapter is the whole class video records and their transcriptions for ten lesson sequences of Teacher 1 (T1) and Teacher 3 (T3).

Subjects

Although three teachers participated in the LPS in Singapore, in this chapter the lessons of only two teachers, T1 and T3, are studied. T1 is from school 1 (SG1) and T3 is from school 3 (SG3). T1 is a female with 21 years of teaching experience. There were a total of 37 students in her class; 15 boys and 22 girls. The students' Primary School Leaving Examination aggregate scores were in the range of 245 – 267 with mean score of 250 and median score of 249. T3 is a male with 15 years of teaching experience. There were a total of 40 students in his class; 25 boys and 15 girls. The students' Primary School Leaving Examination aggregate scores were in the range of 188 – 253 with mean score of 207 and median score of 206. Students in the class of T1 were of higher ability than those in the class of T3.

Data Analysis

The video recordings and transcripts of all the ten lessons for T1 and T3 were viewed and studied respectively to annotate segments of lessons which we refer to as episodes during which i) students were given an opportunity to engage in public talk by their teachers, and ii) students initiated public talk. Having identified the episodes, the duration of each episode in minutes was recorded. This was done as the number of episodes did not provide a good means of representation as the duration of lessons in SG 1 were typically 60 minutes while those in SG 3 were 30 minutes in duration.

The characteristics of the discourse during episodes in which students were given an opportunity to engage in public talk were examined and coded according to Stein's adaptation of the Hufferd-Ackles, Fuson, and Sherin (2004) framework for level of discourse shown in Table 1, and ii) teacher's orientation of classroom discourse following Thompson's et al. (1994) characterisation of conceptual orientation and calculational orientation.

In the process of analysis for level of discourse we found that the descriptors for levels 0 and 1 were adequate for the purpose but several episodes were beyond level 1 but definitely not at level 2. Hence we created level 1^+ , the description of which is shown in Table 2.

Table 2. Revised levels of discourse in a mathematics classroom

Levels	*Characteristics of Discourse*
0	The teacher asks questions and affirms the accuracy of answers or introduces and explains mathematical ideas. Students listen and give short answers to the teacher's questions.
1	The teacher asks students direct questions about their thinking while other students listen. The teacher explains student strategies, filling in any gaps before continuing to present mathematical ideas. The teacher may ask one student to help another by showing how to do a problem.
1^+	**The teacher asks open-ended questions to elicit student thinking and asks students to comment on one another's work. Students give short answers to the questions posed to them.**
2	The teacher asks open-ended questions to elicit student thinking and asks students to comment on one another's work. Students answer the questions posed to them and voluntarily provide additional information about their thinking.
3	The teacher facilitated the discussion by encouraging students to ask questions of one another to clarify ideas. Ideas from the community build on one another as students thoroughly explain their thinking and listen to the explanations of others.

The episodes, during which students initiated public talk, were also studied for the purpose of the talk. The questions posed by the students were examined using the four categories: meaning, method, reasoning and application proposed by Wong and Quek (2010).

DATA AND FINDINGS

In this section the data and findings are presented in order of the research questions presented in the chapter.

How Often Do Students Get an Opportunity to Engage in Public Talk?

Table 3 shows the number of episodes per lesson during which the teachers engaged their students in public talk. As the duration of the lessons were not the same for both teachers it was not appropriate to make any comparison of the number of episodes. We therefore computed the length of time per lesson during which students were engaged in public talk. Table 4 and Figure 1 show the data for T1 and T3 according to the duration of teacher-student public talk.

Table 3. Number of episodes when students were engaged in public talk

	Number of episodes	
Lesson	T1	T3
L01	15	3
L02	9	2
L03	6	0
L04	3	2
L05	7	2
L06	1	1
L07	8	1
L08	4	7
L09	3	3
L10	3	1
Total	59	22

Table 4. Duration of time students were engaged in public talk by T1 and T3

Lesson	Duration in minutes			
	T1		T3	
	Lesson	Students engaged in public talk (%)	Lesson	Students engaged in public talk (%)
L01	54.58	19.59 (35.89)	32.75	7.21 (22.02)
L02	51.95	23.92 (46.04)	34.87	1.34 (3.84)
L03	54.62	12.52 (22.92)	33.42	0.00 (0.00)
L04	60.30	8.28 (13.73)	69.57	3.37 (4.84)
L05	53.00	13.40 (25.28)	37.58	4.67 (12.43)
L06	48.48	2.42 (5.00)	31.50	3.97 (12.60)
L07	54.27	12.57 (23.16)	28.80	0.63 (2.19)
L08	53.83	5.42 (10.07)	67.92	9.61 (14.24)
L09	47.00	7.93 (16.87)	40.32	3.42 (8.48)
L10	54.53	8.86 (16.25)	33.85	0.83 (2.45)
Total	532.46	114.91(21.58)	410.58	35.05 (8.54)

From Table 4, it is evident that students in the class of T1 had more opportunity to engage in public talk with their teacher (21.58%) as compared to the students in the class of T3 (8.54%). During lesson 6 of T1 and lesson 3 of T3 students wrote a mathematics test and hence as shown in Figure 1, the opportunity to engage in public talk by the students in the class of T3 was none and the lowest compared to other lessons of T1. With the exception of lessons 6 and 8, the percentage of time students were engaged in public talk in the class of T1 was always higher than that in the class of T3.

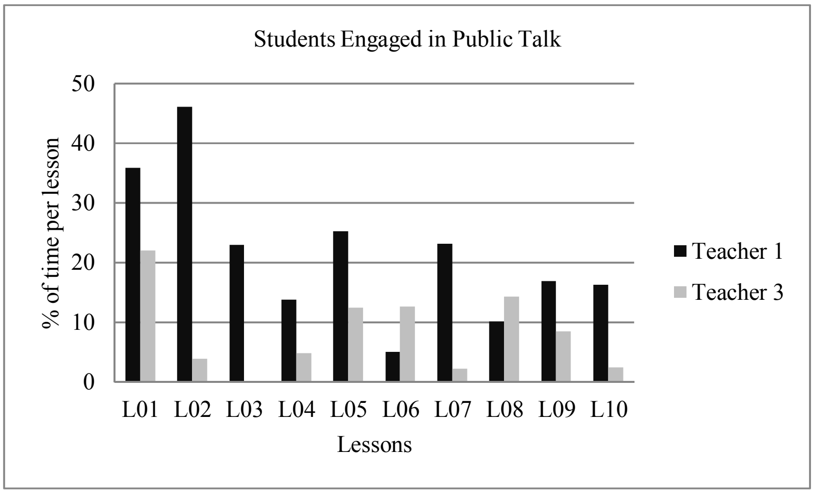


Figure 1. Percentage of time per lesson students were engaged in public talk

What Are the Characteristics of Teacher-Student Public Talk?

Table 5 shows the duration of teacher-student public talk according to the different levels of discourse per lesson for T1 and T3. It also shows for the three levels of talk its' percentage with respect to the duration of talk in the sequence of the ten lessons.

From Table 5, it is evident that the students in the class of T1 engaged in more public talk at level 0 (11.33%) and level 1 (9.01%) as compared to the students in the class of T3 (level 0 – 4.26% and level 1 – 1.81%). However, the students in the class of T3 spent twice as much time for level 1^+ (2.46%) when compared to the students in the class of T1 (1.24%). It is also apparent from the Table that when we consider only the teacher-student public talk time for the ten lessons collectively, both T1 and T3 spent about the same time, i.e., approximately 50% of the time for Level 0 of the discourse. However, the proportions of time spend on the other two Levels, 1 and 1+, were significantly different. T1 spend about 40% on Level 1 and less than 10% on Level 1+, while T3 spend about 20% on Level 1 and about 30% on Level 1+.

Table 5. Duration of teacher-student public talk by level of discourse for T1 and T3

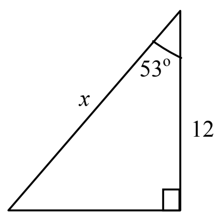
Lesson	% of time per lesson					
	Level 0		Level 1		Level 1+	
	T1	T3	T1	T3	T1	T3
L01	16.12	11.54	12.13	10.47	7.64	-
L02	20.35	1.18	21.02	2.06	4.68	-
L03	18.22	-	4.71	-	-	-
L04	13.73	2.90	-	1.94	-	-
L05	25.28	-	-	-	-	12.43
L06	-	12.60	5.00	-	-	-
L07	7.59	-	15.57	2.19	-	-
L08	2.32	8.39	7.75	0.71	-	5.05
L09	-	3.52	16.87	-	-	4.96
L10	7.26	-	8.99	2.45	-	-
Total	11.33	4.26	9.01	1.81	1.24	2.47

Level	% of total time for all 10 lessons	
	T1	T3
Level 0	52.50	49.88
Level 1	41.75	21.20
Level 1+	5.75	28.92

Level 0 of teacher-student discourse. At this level of teacher-student discourse the teacher mainly asked the students closed questions and students gave short answers. The teacher affirmed the accuracy of the answers and explained the underlying mathematical ideas almost always. Both teachers T1 and T3 spend almost half of the teacher-student public talk time during the sequence of ten lessons each engaging students in this type of discourse. Table 6 shows examples of teacher-student discourse at the level.

Table 6. Episodes of level 0 teacher-student discourse in the classes of T1and T3

Teacher/ Lesson/ Episode	Mathematical Content	Teacher's Questions	Student/s' Responses
T1 L02 Ep 04	$2.8 \times 10^4 + 3.2 \times 10^5$	Look at these two powers of ten, which is bigger? 10^4 or 10^5	10^5 (chorus)
	$2.8 \times 10^4 + 3.2 \times 10 \times 10^4$	10^5 is bigger. Now this is what we'll do. This is smaller, we put down 2.8×10^4. Okay we use 10^4. Now as for this one it becomes $3.2 \times 10 \times 10^4$. We break down 10^5 into 10×10^4. So that this and this are the same.	

	$2.8 \times 10^4 + 32 \times 10^4$	So I will have $2.8 \times 10^4 + 32 \times 10^4$. Okay. What's your next step?	Add, add (chorus)
	$2.8 \times \underline{10^4} + 32 \times \underline{10^4}$	Both (underlined 10^4) are the same right: Add?	Add (ten to the power of four) (chorus)
		2.8 + 3.2 right?	32 (chorus)
	34.8	Is that the answer? What is missing?	No The 10^4 (chorus)
	34.8×10^4	Good. Okay, but this is not in standard form. Is it in standard form?	No (chorus)
	3.48×10^5	No, so I must convert to standard form. So my final answer is…	
T3 L08 Ep 04		Okay now, (called on a student) you must tell me, which ratio you're going to use now? Whether you're going to use tangent, sine or cosine?	Er… cosine (individual student)
	$\cos 53^o = 12/x$ $x = 12\cos 53^o$	Cosine? Is (student's name) correct?	Yes (chorus)
	$x\cos 53^o = 12$ $x = 12/\cos 53^o$ $= 19.939$ $= 19.94$ units	(Student name) Don't do. Is (student name) correct? What did (student name) say?	Cosine (individual student)
	$x = \cos (12/53)^o$	Cosine? So let's check. Where is the, what's this side?	Hypothenuse (chorus)
		What is this side?	Adjacent (chorus)
		Is it opposite?	Adjacent (chorus)
		It's adjacent. Okay so we have a A, we have a H. yes or no? A and H. Now you look at the .. consult this lady again. Toa Cah Soh okay? So we have A and H. So which one must we use? Cosine right.	Yes (chorus)

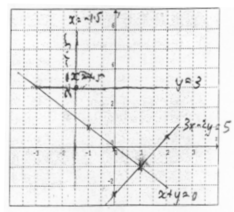
From Table 6, it is evident that during level 0 of teacher-student discourse in both classes the teachers mainly asked questions to check on students' understanding. The responses from the students were short and always in chorus form unless the teacher specifically asked a student to respond. The teachers explained further when students were unable to give expected answers.

Level 1 of teacher-student discourse. At this level of teacher-student discourse the teacher asks students direct questions about their thinking while other students listen. The teacher explains student strategies, filling in any gaps before continuing to present mathematical ideas. T1 spend about 40 % and T3 about 20% of the teacher-student public talk time during the sequence of ten lessons each engaging students in this type of discourse. Table 7 shows examples of teacher-student discourse at the level.

Table 7. Episodes of level 1 teacher-student discourse in the classes of T1 and T3

Teacher/ Lesson/ Episode	Mathematical Content	Teacher's Questions	Student/s' Responses
T1 L07 Ep 01		[Teacher calls a group to present their answers following group work activity in the class]	
	John's pay →: 100% Cut by 15% and left → 100% - 15% = 85% Increased by15% $= \frac{115}{100} \times 85 = 97.75$	Okay, would you like to present your solution.	John's pay is 100%. Then it is cut by 15% and left is 85%. Then the pay increased by 15%, then now he will get 97.75% of his original pay.
		So does he get more or less? Before the	Get less than 2.25%
		Yes, he got less less by 2.25% right? Good. Now this is one way of solving.	
		[Teacher calls on another group to show their solution]	
	If John's pay is 100*x*, John's pay in the certain year is	We have another way by the other group. Can you show us? They made use of X.	If John's pay is 100x, John's pay in the certain year is

	John's pay after increase $100x > 97.75x$ Ans: Less		John's pay after the 15% increase is. As a result the answer is less.
		Okay very good. Okay I am very impressed.	
T3 L04 Ep 02	$3x - 2y = 5$ $-2y = -3x + 5$ $y = \frac{-3x+5}{-2}$ $y = \frac{3}{2}x - \frac{5}{2}$	[Student name] can you see this line? Is it sloping upward or downward, this line? From left to right?	Downward (individual student)
		Huh? Downward. You're guessing. Why?	Minus two and a half (individual student)
		Minus two and a half? This give you the, this give you … what is this? You still cannot remember. Okay now you look at this equation here. Okay I want you to focus on this equation. Where is your **m**?	Three over two (chorus)
		Shh, I'm asking [student name]. Can you please stand up? Where is your **m** here?	Three over two (individual student)
		Stand up. **M** is three over two. What does **m** represent?	*y*-intercept (individual student)
		m is your *y*-intercept ah? Are you telling … what does **m** represent?	Gradient (individual student)
		Gradient. Where's your **c**? What's the **c** here?	Five over two (individual student)
		Are you sure it's positive five over two? What does c-represent?	*y*-intercept (individual student)
		y-intercept . Sit down. Okay so over here, okay if **m** is positive, so it's upward sloping or downward	Yes (chorus)

		sloping? **m** represent the gradient right? Positive means I told before is upward sloping means what, it's going this way, left to right it's going upward this way right?	
		Okay and where's the y-intercept? Negative? Five over two or two and a half. Okay so basically when you look at your, your uhm grid here, okay you're going to plot the points to draw a straight line and this straight line is a positive gradient sloping upward intercept the y axis at minus two point five. So what does it show, it shows that.. it'll be something like this, okay two point five is here. And the line will go this way up because it's a sloping upwards.	Five over two (chorus)

In Table 7, T1 in L07 asked two groups of her students to share their thinking about the same task with the rest of the class. The teacher-student public talk introduced the class to two ways in which the task given to the students as part of their group work activity could be solved. The direct questions asked by the teacher when the groups presented clarified students' thinking. T3 in L04 clarified students' knowledge about the gradient intercept form of an equation of a straight line using a worked example and a graphical representation. Both T1 and T3 in the episodes shown in Table 7, focussed on engaging students to clarify their thinking by asking them direct questions at appropriate junctions.

Level 1⁺ of teacher-student discourse. At this level of teacher-student discourse the teacher asks students open-ended questions to elicit student thinking and asks students to comment on one another's work. Students give short answers to the questions posed to them. T1 spend about 5 % and T3 about 30% of the teacher-student public talk time during the sequence of ten lessons each engaging students in this type of discourse. Table 8 shows examples of teacher-student discourse at the level.

Table 8. Episodes of level 1+ teacher-student discourse in the classes of T1and T3

Teacher/ Lesson/ Episode	Mathematical Content	Teacher's Questions	Student/s' Responses
T1 L01 Ep 15	$\frac{3.6 \times 10^4}{10^3}$ $= 3.6 \text{ x } (10^4 \div 10^3)$ $= 3.6 \text{ x } 10^{4-3}$ $= 3.6 \text{ x } 10$ $= 36$	Alright I asked him to come forward and show the working. What he did was, he notice that it's $10^4 \div 10^3$, so he simplify first. Alright. He takes the power 4 – 3.	
	$\frac{3.6 \times 10^4}{10^3}$ $= \frac{36000}{1000}$ $= 36$	I notice some pupils do it this way. Now both way are acceptable, but which one do you think , er, which one would you prefer?	First one (chorus)
		Why? Why the first one?	More meaningful (chorus)
		Because what happen if I give you $\frac{3.6 \times 10^7}{10^5}$? Then you end up writing a lot of zeros do you agree?	Yes (chorus)
		Okay. So it'll be easier if you simplify, alright, the base first.	
T3 L05 Ep 01	$x^2 + (x + 1)^2 = (x + 2)^2$ $x^2 + x^2 + 1 = x^2 + 4$	So $x^2 + x^2 + 1 = x^2 + 4$ Do you have this like that?	Yes (chorus)
		Is it correct? Who said yes?	Yes (chorus) Huh? Yes. (chorus) Wrong, wrong (chorus)
		Yes right or wrong? [Student name] you shake your head. So why is it wrong? Correct what $(x + 1)^2 = x^2 + 1$ correct or not? Wrong?	Wrong Plus $2x$

		What should it be?	$x^2 + x^2 + 2x + 1 = x^2 + 4x + 4$
		You say $(x + 1)^2$ if you expand this thing out what will you get?	$x^2 + 2x + 1$
	$x^2 + x^2 + 2x + 1 = x^2 + 4x + 4$	Do you hear what [student name] said? Okay now this is the common mistake that many of you will make. Okay when you expand it out… okay you should have another term.. $2x$. And this one x^2 + 2 AB. Remember your 2AB so $2 \times x \times 2$ you have $4x + 4$	

From the examples in Table 8, it is evident that at Level 1[+] of teacher-student discourse the teachers in both classes asked open-ended questions such as “Which one would you prefer? Why? Why the first one?” and “So, Why is it wrong?” to elicit students’ thinking on the work presented by the students on the board during classwork. But the students in both schools only managed to give short answers without explaining their answers further and the teachers also did not probe them further.

What Are the Teachers’ Orientations of Discourse (Conceptual or Calculational)?

Table 9 shows the duration of teacher-student public talk according to the orientation of discourse per lesson for T1 and T3. It also shows for both the orientations its’ percentage with respect to the duration of talk in the sequence of the ten lessons. From the table it is apparent that the orientation of T3’s discourse was predominantly calculational. He spent almost 100% of the time for the teacher-student talk in his class in this orientation. However, this was not the case for T1. About two thirds of her class time during teacher-student discourse was in the calculational orientation while the other third was in the conceptual orientation. Table 10 shows examples of episodes that illustrate conceptual orientation and Table 11 shows examples of episodes that illustrate calculational orientation.

Table 9. Duration of teacher-student public talk by orientation of discourse for T1 and T3

Lesson	% of time per lesson			
	Orientation of teacher-student talk			
	Conceptual		Calculational	
	T1	T3	T1	T3
L01	13.61	-	22.28	22.02
L02	14.34	2.06	31.70	1.78
L03	-	-	22.92	-
L04	-	-	13.73	4.84
L05	16.26	-	9.02	12.43
L06	5.00	-	-	12.60
L07	4.55	-	18.61	2.19
L08	0.46	-	7.75	14.24
L09	2.83	-	14.04	8.48
L10	8.97	-	7.28	2.45
Total	6.73	0.18	14.85	8.36
Orientation	% of time for all 10 lessons			
	T1		T3	
Conceptual	31.19		2.11	
Calculational	68.81		97.89	

Table 10. Episodes of teacher-student discourse with conceptual orientation

Teacher/ Lesson / Episode	Teacher's Questions	Student/s' Responses
T1 L05 Ep 07	Alright. Look at these two pictures. I'm sure you know what's the name of this figure right? What is it called?	Square *(individual student)*
	Good. And what about the one on the right?	Rectangle *(individual student)*
	A rectangle. Are they similar?	No *(chorus)*
	Why not? They have equal corresponding angles.	Corresponding sides are not *(individual student)*
	Are they similar?	No *(individual student)*
	Why not?	They don't have the same … They don't have the same ratio for the corresponding sides. *(individual student)*
	Yes. The ratio – the corresponding ratio of the corresponding sides are not equal okay?	
T3 L02 Ep 02	Why I don't do that over here in Pythagoras Theorem. I didn't bother to put plus and minus	Not possible *(individual student)*

Not possible? Why not? [Student name] You know why? What is your c? What does c represent? The small letter c what does this represent in the question?	Line *(individual student)*
The line. Can the line be a negative or not?	No *(chorus)*
Can length be a negative?	No *(chorus)*
No right? So why you bother to put plus and minus? You know that it can it must be C must be always positive value. Are you following what I'm trying to tell you?	Yes *(chorus)*

From Table 10, it is apparent that both teachers, T1 and T3 used questions such as "Why are they not similar?" and "Why don't I do it here?" to illicit conceptual knowledge of their students and also place emphasis on the process of student learning.

Table 11. Episodes of teacher-student discourse with calculational orientation

Teacher / Lesson / Episode	Teacher's Questions	Student/s' Responses
T1 L01 Ep 04	Is this correct? Can you tell me what is the answer for this? Is this correct by the way?	No *(individual student)*
	Yes or No?	No, they can't be. *(individual student)*
	No. Why?	Plus *(chorus)*
	Good, it is plus. What should the correct answer be?	Eleven thousand *(individual student)* Seven thousand *(individual student)*
	What is the correct answer? Yes. Sorry?	Eleven thousand *(chorus)*
	Eleven thousand. Okay. Eleven thousand. Do you know how we get eleven thousand?	Yes *(chorus)*
	Good. Alright. Eleven thousand. So be very careful ah. You can add the power if its multiplication and the base are the same.	
T3 L08 Ep 07	[Student name] What do you think? Which ratio would you use to find ***X***?	Cosine (individual student)
	Use cosine? Why do you use cosine	Twelve (individual student)

because X is opposite and then what?
You're using fifteen or twelve?
Twelve? Okay. Now in this question
if many information are given, you
can use cosine like what [student
name] has suggest. Okay or you are
going to use fifteen you can use sine.

From Table 11, it is apparent that both teachers used direct questions to get numerical answers from their students when they were thinking aloud the steps of tasks they engaged their students to solve during demonstration. Teachers were contented when students provided the correct numerical answers and did not quiz them any further.

Do Students Initiate any Public Talk with Their Teachers or Peers? If So, What Was the Purpose of the Talk?

Students did initiate public talk with their teachers. Table 12 shows the number of episodes and the duration of time per lesson during which students' initiated student-teacher discourse as part of the public talk during lessons.

Table 12. Student initiated content-learning discourse

Lesson	Episodes			
	T1		T3	
	Number	Duration in minutes (%)	Number	Duration in minutes (%)
L01	2	4.32 (7.91)	0	-
L02	0	-	1	1.25 (3.58)
L03	2	2.40 (4.39)	0	-
L04	3	6.58 (10.97)	0	-
L05	1	0.65 (1.23)	0	-
L06	0	-	0	-
L07	3	1.37 (2.52)	2	0.62 (2.15)
L08	1	2.05 (3.81)	2	2.00 (2.94)
L09	2	2.83 (6.02)	0	-
L10	0	-	0	-
Total	14	20.20 (3.79)	5	3.87 (0.94)

From Table 12, it is apparent that in both classes student initiated public talk occurred infrequently. In the class of T1, over a sequence of ten lessons, students initiated talk on 14 occasions for a total duration of 20.20 minutes, i.e. 3.79 % of the time. In the class of T3, over a sequence of ten lessons again, students only initiated talk on 5 occasions lasting a total duration of 3.87 minutes, i.e. 0.94% of the time. On all the occasions, students initiated talk with their teachers only. Table 13 shows representative episodes of the different purposes for which students initiated public talk during the ten lesson sequences of T1 and T3.

Table 13. Episodes of student initiated content-learning discourse in the classes of T1 and T3

Teacher / Lesson / Episode	Students' Questions	Teacher's Responses
T1 L03 Ep 07	Can draw model? (individual student) Secondary school cannot use model (individual student)	Can you can do. You can use any method.
		(talks to the whole class) Okay somebody asked me this question "Can we draw model?" Yes, by all means go and draw model. And then some of you say but I thought in secondary school we cannot draw model. No, if the method works, why not? Go ahead … Alright some of you may want to use table
	Bar model (individual student)	Ah you can draw bar model can. Algebra also can yes. .Now not necessary we have to use algebra to solve all the time. Alright, for certain types of question model may be easier.
T1 L04 Ep 01	The question is illogical (individual student)	What illogical? Why do you say it's illogical?
	Because they say that the total cost of producing 600 copies of the magazine so each copy is … so how can … but the answer given is ….. 600 copies (individual student)	One magazine got 32 pages, one copy yeah? So you must have 600 copies of magazines
	Yeah but the answer given is 600 plus 32 pages (individual student)	Okay. You read the typing is one page $3 right? So 32 page will be $96 correct?
	Yeah. That they say it's typing.	Okay wait. I think I see your point. Can I borrow your

		calculator? So you $96?
	Plus 2 after that	Yeah plus 6 times 18.5. Yeah then you get 207 correct.
	Correct	Okay? One copy is $3. 32 sorry one page is $3 so 32 pages will be? $96 correct?
	Yes	Then for every 100 copies is $18.50 so 600 copies is18.50 times 6.
T3 L02 Ep 03	I don't know why the answer for this one cannot be negative.	This one? Why is it cannot be negative? That's what I'm trying to explain to you why it cannot be negative.
	Don't understand mah	That's what I'm trying to explain to you all just now, I didn't bother to put plus minus, **C** cannot be negative because I just asked [student name] what does **C** represent here [student name] ? What does **C** represent in the question?
	Side	Yeah the side. It's the length of the longest side in the right angle triangle right or not? Can the length be a negative value?
	No	Can or not?
	Student shake his/her head	Cannot right? A length of a side of a polygon it cannot be a negative value so I don't bother to put plus minus. That's the reason why.
T3 L07 Ep 01	What happen if the answer is one? What happen if exactly one? The ratio is one? (individual student)	The ratio is negative?
	No the ratio is one.	The ratio is one? Yeah lah the ratio can be one what, there. I can

	go up to one. When it's one to up to one what does it mean? It means that the opposite and the adjacent are the same length. Do you agree?
Oh okay.	Yeah it's the same length what so something the same length over equal to one isn't it? Alright it can be equal to one. Alright possible.

From Table 13, it is apparent that students in both classes initiated public talk for various reasons. In episode T1-L03-Ep 07, the student asked the teacher if he could use the method of drawing models to find the solution of an algebraic problem. In

Episode T1-L04-Ep 01, the student raised a concern about a likely error in a textbook question that the teacher had asked the class to work on. In both the episodes T3-L02-Ep 03 and T3-L07-Ep 01, students sought further clarifications about the concepts the teacher had explored during the lessons.

DISCUSSION

The data and findings presented in this chapter will be discussed in this section according to the research questions investigated.

During Content-Learning Classroom Discourse How Often Do Students Get an Opportunity to Engage in Public Talk?

It was found that in the two grade 8 mathematics classes of the competent teachers of the LPS in Singapore there was an apparent lack of teacher-student public talk. Over the ten lesson sequence in the class of T1 from SG 1, students were engaged in discourse by their teacher for 21.58% of the time. Similarly, T3 in SG 3 engaged his students for only 8.54% of the time. As the teacher was responsible for controlling all the talk that occurred while the class was officially in session, it is apparent from the above findings that the lessons of both T1 and T3 were dominated by teacher talk. Both T1 and T3 during teacher talk expounded mathematical concepts and problem-solving skills mainly through the use of examples (Seah, Kaur, & Low, 2006). Students were generally not engaged in co-constructing knowledge with their teachers. Both teachers spend considerable amounts of time explaining concepts and illustrating them (Kaur, 2009).

During Content-Learning Discourse What Are the Characteristics of Teacher-Student Public Talk?

In both classes of T1 and T3, the level of content-learning discourse during teacher-student public talk did not reach levels 2 and 3 as in Stein's adaptation of the Hufferd-Ackles, Fuson, and Sherin (2004) framework. The discourse was only at levels 0, 1 and 1^{+}. Level 1^{+} was created by the researchers as they found several episodes of teacher-student public talk that was beyond level 1 and not at level 2. This shows that all the teacher-student content-learning discourse in both the classes of T1 and T3 merely focussed on teachers asking the what, which and how questions to evaluate student understanding of knowledge they were expounding through worked mathematical examples thereby clarifying the conceptual knowledge they were disseminating. It may be said that the talk centred around showing and telling or explaining, typifying traditional teaching (Pimm, 1987).

Examining more closely the percentage of teacher-student public talk time, it was found that both T1 and T3 spend about half (50%) of the time at level 0 of the discourse. At this level, the teacher mainly asked the students closed questions and students gave short answers. While T1 spend about 40% on Level 1 and less than 10% on Level 1+, T3 spend about 20% on Level 1 and about 30% on Level 1+. It is apparent from the episodes presented in the chapter that T3 addressed some common misconceptions that his students were developing during the course of the lesson. He also reframed from giving them the answers, but rather engaged them in thinking through it. In both classes, the teacher-student discourse at level 1^{+} demonstrated that teachers were asking open-ended questions but lacked probing for reasons or justifications of answers students provided to their questions. Hence there was a lack reviewing and restructuring to develop students' own understanding of mathematics (Anghileri, 2006). It may be speculated that the actions on the part of the teachers may be due to the objectives of their questions, often dip-stick approaches for assessing student understanding or perhaps lack of time or expertise to engage students in dialogic talk.

During Content-Learning Discourse What Are the Teachers' Orientations of Discourse (Conceptual or Calculational)?

It is apparent from the data presented, that in both the classes of T1 and T3 there were both conceptual orientation and calculational orientation during the teacher-student public talk as part of the content learning discourse. However, in the class of T1 almost twice as much time was spend on calculational orientation than on conceptual orientation while in the class of T3 98% of the time was devoted to calculational orientation and a mere 2% to conceptual orientation.

Given that the students in the class of T1 were of higher ability than those in the class of T3, it appears that T3 placed a lot more emphasis on "doing it right" via the calculational orientation of teacher-student content-learning discourse in his class. It may also be speculated that in both the classes the marked emphasis on calculational orientation may be partly derived from assessment requirements as often teachers tend to teach to the test. Mathematics tests generally at national levels in Singapore test procedural/calculational knowledge. There is no doubt that sound conceptual knowledge can help one to weather all sorts of test questions but often give a finite duration of time, teachers tend to take a safe trajectory by ensuring that procedures and calculation techniques are honed well in their students.

During Content-Learning Discourse Do Students Initiate Any Public Talk with Their Teachers or Peers? If So, What Was the Purpose of the Talk?

In both the classes of T1 and T3 students initiated public talk with their teachers and peers rather infrequently. In the class of T1, over a sequence of ten lessons, students initiated talk on 14 occasions for a total duration of 20.20 minutes, i.e. 3.79 % of the time. In the class of T3, over a sequence of ten lessons again, students only initiated talk on 5 occasions lasting a total duration of 3.87 minutes, i.e., 0.94% of the time. On all the occasions, students initiated talk with their teachers only. The purpose of the talk was to clarify doubts about any preferred methods of solution, seek further explanations on concepts they had difficulty with and to draw the attention of the teacher to some irregularities in textbook questions. It is apparent that the questions students asked had to do with the meaning and method aspects of learning (Wong & Quek, 2010). This finding shows that students were concerned with getting the 'content right' and the 'how to do it'. In addition, the very limited initiation of talk by the students perhaps sheds some light on the culture of learning in the classes of T1 and T3 that may be worth exploring further in a future study.

CONCLUSION

The findings in this chapter have shed light on the nature of teacher-student content learning discourse in two grade eight classrooms in Singapore. The data presented in this chapter cannot be used for generalisation of classrooms in Singapore. Nevertheless, we can say that in the classes of two competent teachers who participated in the LPS in Singapore the content-learning discourse was dominated by teacher talk and student listening. Student-teacher interaction for the most part, were related to the teacher's assessment of students' progress in understanding the demonstrated problem solution methods and this attributed to the calculational orientations of most episodes of the discourse. The apparent lack of student-initiated public talk was a consequence of the instructional organisation of the lessons in repeated rounds of teacher demonstration, seatwork, and whole class review of student work and common misconceptions. Lastly both teachers and students were focussed on getting the meaning and method correct for the content knowledge during the lessons.

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