A Snapshot of the Discourse Used in Mathematics where Students Are Mostly Pasifika (a Case Study in Two Classrooms)

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This report concentrates on the discourse that one teacher used with her students who were predominantly Pasifika. It shows that the teacher used questioning and response styles in her interviewing and class lessons that were consistent with the pedagogy of the Numeracy Development Project (NDP). There is some evidence that students used some characteristics of this discourse with one another when working on problems together. This discourse emphasises explaining one's thinking rather than merely providing correct answers. There is less evidence that the NDP places emphasis on the use of correct mathematical terms and on presenting complete evidence of the forms that guide thinking in more advanced mathematics. It is suggested that an emphasis on terms and logical explanations in mathematical discourse be added to the NDP to increase the likelihood of all students having an equal chance of success in mathematics.

The specific register of mathematics often receives less attention in New Zealand classrooms than it requires. The term "mathematics register" covers both the terms that are specific to mathematics and the ways of presenting mathematical arguments. Some studies of the mathematics register have concentrated on classroom discourse (e.g., Cobb & Bauersfeld, 1995; Khisty & Chval, 2002; Moschkovich, 2003; Pimm, 1987). Other researchers concentrate on specific terms (e.g., Cowan, 1991; Riley & Greeno, 1988) or linguistic forms (e.g., Presmeg, 1997). There is also a considerable amount of literature on mathematical discourse and learners of English as an additional language (e.g., Hofstetter, 2003; Moschkovich, 1999).

There are many interrelated issues that may affect the achievement of Pasifika students. In South Auckland, these may include family income, health, stability of housing and schooling, number of people in the household, and parental understanding of what is required to succeed in mathematics in New Zealand schools. Many of these issues are not under teachers' control. However, the language used in mathematics classrooms can be strongly influenced by teachers. A very striking report of a teacher's ability to improve the mathematical achievement of students in her classroom through the use of the accurate mathematics register is that reported by Khisty and Chval, 2002. The teacher in that report took a class of students with English as an additional language from being one or two years behind grade level in achievement to being one or two years above grade level. Students were reported to leave her class "smart in mathematics …" (p. 157). That report portrays how she modelled sophisticated mathematical terms and discourse and then encouraged her students to use this same language in their discussions. The teacher appeared to have a good knowledge of mathematics and its terminology, but language was the avenue through which she let her students gain this knowledge and ability to discuss mathematical objects and relationships.

Our study looked at two teachers in different schools who taught classes in which nearly all students were Pasifika. Both teachers had participated in NDP training in past years. They turned out to be markedly different in their use of language, both in assessing their students and in their classroom discussions. The teacher who is the focus of this report was picked up late in the year when the other teacher left her school. This was serendipitous as it provided a useful contrast. We concentrate here on the teacher picked up later in the year, who used language more effectively, with comments on the other teacher and her students for contrast. Because

this focus teacher and her class were videotaped only in the final term, it is not possible to indicate changes in students' language during the year. This teacher has agreed to be observed over three terms of 2005, in which we hope to be able to observe development of students' mathematical discourse.

Method

Participants

The teacher who is the primary focus of this report is a New Zealand European with relatively few years of teaching experience. We will call her Ms Connor. She taught a class of 25 year 5 and 6 students, 21 of whom reported that they were of Tongan, Niuean, Cook Island, and/or Samoan descent. Three were Māori and one was Australian. Some of these students were born in New Zealand, and some had come to New Zealand within the past month. The school was classified as decile 1, as was the school of the comparison teacher and class. We will call the teacher used for comparison Ms Regal. She taught a year 4 class that had only one non-Pasifika or Māori child in it. Both teachers appeared to be popular with their students.

Method

The teachers were videotaped while giving four or five individual assessment interviews and while teaching at least one whole class. For both teachers, a period of whole-class teaching was videotaped, followed by videotaping of small groups of students carrying out assigned mathematical tasks. By chance, both teachers were teaching a unit from the Statistics strand. In both cases, the first author observed classes before videotaping and spoke informally with the students to allow them to become familiar with her and to get their consent to be videotaped.

Analysis

Digital videotapes were transferred to DVDs, transcribed, and then analysed. Intensive analysis was done on similar sections from each teacher and any patterns checked with the full transcripts to see whether or not they were representative. The interview that appeared to have the most input from the student was analysed for each class, and the patterns found in this interview were compared with other interviews to see if they were representative. The entire teacher-led portion of the lesson and selected student dialogues were analysed. These selected dialogues were also compared with other dialogues in each class to see if they were representative. Categories used for analysis included type of question, wait time as evidence of listening, language patterns and utterance type of both teachers and students, focus of the discourse, expected audience, relative number of words spoken by teachers and students, and mathematical vocabulary.

Findings

Discourse in interviews and in class

Classroom discourse has several components that can be distinguished. Although this study separates some of these components, this is for analysis only. Dialogue or conversation is an integrated whole, particularly wherein it involves expectations for each party's contribution.

From the data available, we can identify characteristics of the teacher's questioning, the length of time that she waited for students' answers, her expectations of the students as seen in her response to students' responses, and the focus of the dialogue, especially whether the focus was on answers or on the thinking process. From our data, we can examine these in both the Numeracy Project Assessment (NumPa) or Global Strategy Stage (GloSS) interviews that set the style for mathematical discourse, in the one class lesson transcribed for each teacher and in one conversation between students while working on a set of problems.

The teacher's questioning, wait time, and responses to students

The NumPa sets the model for how the teacher is to ask questions and the expectations for responses. In the knowledge section, these are closed questions that require one answer. For the strategy questions, they are relatively open questions that request a student to explain his or her thinking. Focus here is only on the strategy questioning.

Ms Connor's questioning was exactly as prescribed in the NumPa document, although she had memorised the script and presented it in a conversational tone. Her questioning made it clear that she was interested in how students thought rather than in particular answers.

She waited for long periods for students to answer. Several of these wait times were over 30 seconds and one was 48 seconds. An example was:

T: At the car factory they need 4 wheels to make each car. How many cars could they make with 72 wheels?
S: (after 41 seconds) Not sure.
T: Not sure. You don't want to just give it a try?
S: (after 48 seconds) Oh, I lost my count.
T: OK, do you want to tell me how you were working it out so far?
S: I was using my four times table and 4 wheels is one car, 8 wheels is 2 cars.
T: Working it out that way.

This passage also provides evidence for the teacher's expectations of the student. The student's responsibility was to think how to do the problem and to explain his thinking rather than just come up with an immediate and accurate answer. Pimm (1987) wrote of "allowing the students thinking time" and giving students "control of the spoken communication channel" (p. 51), both of which assume that teachers will wait for answers. Ms Connor's response indicated that she appreciated the way that the student was working out the answer and that his explanation of his thinking was adequate for her to understand the strategy used for this item. Another indication of the importance that this teacher placed on the student doing the thinking in the interviews was the ratio of words that she used in comparison to those used by the student. Examination of other interviews by Ms Connor showed this to be a typical pattern of questioning, listening, and responding. The ratio for the interview analysed for Ms Connor was 3:2. In comparison, the ratio of words used by Ms Regal to that of her students was 3:1 in the interview in which the student had said the most. Many of the student's words in that interview were the result of Ms Regal asking him to read the question. That teacher had very few periods of silence. In another of her interviews, the student spoke 6 words during 4 minutes and 5 seconds of interview while the teacher spoke 405 words. This interview would have a ratio of 68:1. It appeared that if Ms Regal thought that the student was not going to succeed, she reworded the question, presented materials to help the student work the problem out, and sometimes talked over the student in her eagerness to have the student succeed. This characteristic of teachers, to have their students succeed, preferably by telling them because the teacher knows the answer, has been called "teacher lust" (Maddern & Court, 1989). It is a

characteristic that all teachers need to be aware of and control if they want their students to do the thinking.

A teacher who adopts the pedagogy of the NDP will have some of the same questioning and response techniques in her class teaching, although class teaching will also have some instances of instruction when appropriate. The students working in groups should also adopt some aspects of the same discourse, in that they should be interested in each other's thinking and ask for it to be explained when necessary. They also need to be able to evaluate their own answers. In the portion of the class that was led by Ms Connor, she uses a similar pattern of acknowledging but not immediately evaluating students' responses. She asks for other students' responses and then asks them to evaluate. The following transcript comes from the introduction to a probability lesson about playing cards in which students were asked "Can you tell me using 'likely', 'unlikely', and 'impossible' that she would pick a card that would be less than ten."

T What do you think, Chris?
S1 Unlikely.
T Unlikely. OK, what do you think?
S2 Likely.
S3 Likely.
S4 Likely.
S5 Likely.
T Is there any way we can prove this?

The balance of teacher and student talk in a classroom is a good index of whose job it is to do the thinking, as indicated in the quotation from Pimm (1987) given above. The ratio of teacher to student talk is usually much higher in the period in which the teacher is working with the whole class. For Ms Connor it was 5:1, and for Ms Regal it was 7:1. The pattern of classroom discourse is usually that of T, S1, T, S2, T, S3, and so on, and can be pictured as a star, with the teacher at the centre. This pattern is traditionally that of teacher's initiation, students' response, and teacher's evaluation (IRE) (see Cazden 2001). This pattern assumes that teachers are asking questions that they know the answers to and the students' task is to find the answer that the teacher has in mind. Frequently the teacher does the vast majority of the talking and presumably of the thinking.

While Ms Regal used this pattern for most of the whole-class session, Ms Connor rarely used an IRE pattern of discourse in the lesson analysed. The ratio of teacher's words to students' words in this instruction period was 5:1, with many of the teacher's words being ones that showed that she was listening, like "OK" or "yes". Her students asked questions of one another in the whole-class session, sometimes spontaneously and sometimes when prompted. She often revoiced the student's answers. This is also a technique evident in the lesson scripts of the NDP. Revoicing provides a second opportunity for students to hear a good model of speaking (Khisty and Chval, 2002). O'Connor & Michaels (cited in Forman, Larreamendy-Joerns, Stein, & Browns, 1998, p. 531) believe that it may also help students to "see themselves and each other as legitimate participants in the activity of making, analysing, and evaluating claims, hypotheses, and predictions". The teacher's discourse is the same regardless of students' ability. This high expectation of quality thinking means the students are not restricted by the "discourse of the 'less able'" as Brown, Eade, and Wilson (1999) phrase it. Figure 1 shows the discourse pattern of a section of this class lesson.

In this analysis, claims are answers without justification and warrants are explanations (Krummheuer, 1995).

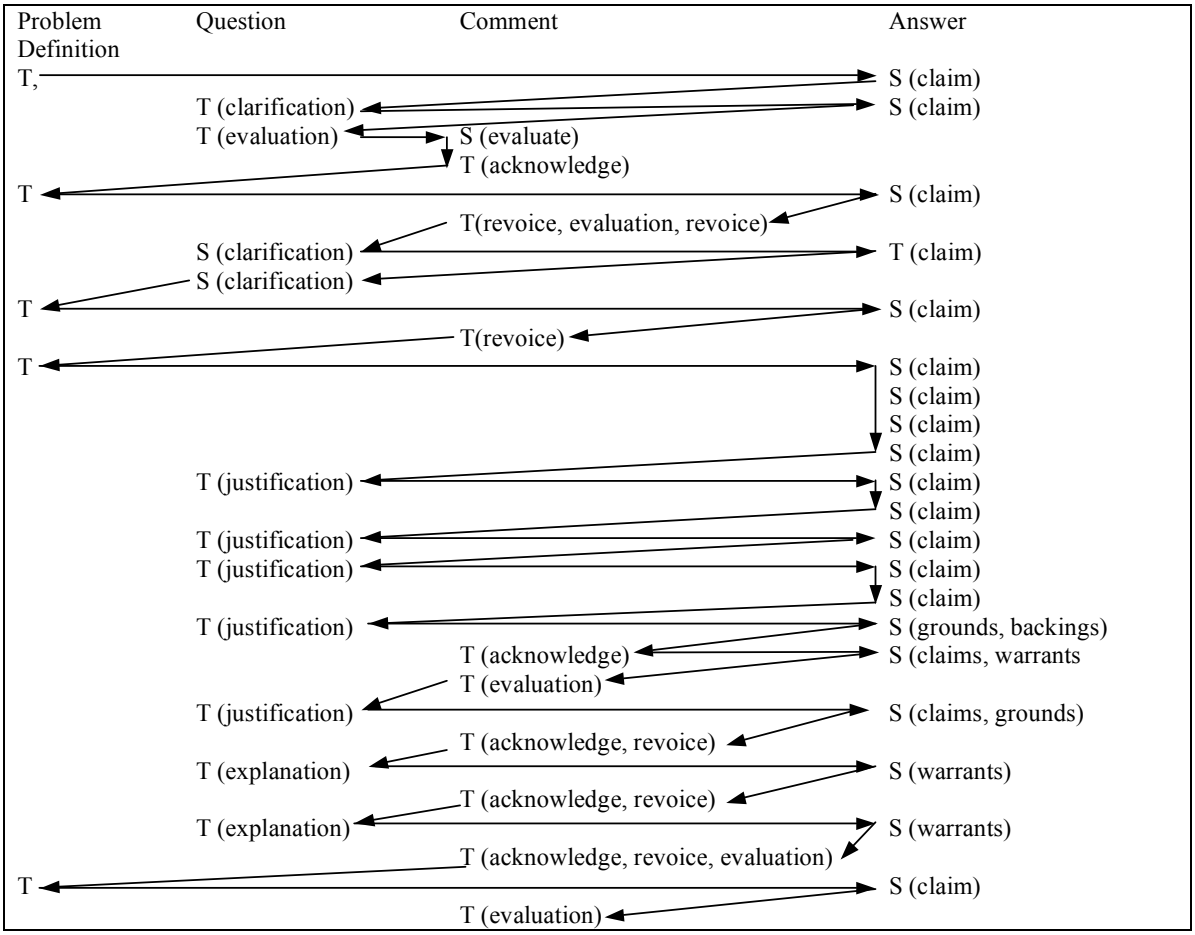

Figure 1. Discourse pattern of whole class portion of Ms Connor's lesson on probability

Note that in Figure 1 most of the teacher's follow-up questions are for justifications or warrants. She does give explanations when she believes they are needed. Only at the end of the extended dialogue does she evaluate the students' work.

Audience

The students use self-talk (talking to themselves as they work out a problem) in the whole-class section of the lesson. While the teacher does not think aloud herself in this lesson, she gives the students time for this, saying, "Give him time to think." One student mumbles his answer to himself and then faces the class and explains his thinking to them. Twice in the lesson the students face the class to explain their answers. The student takes the role of the teacher.

Student-to-student discourse

The real test of how well students understand this pattern of discourse is whether or not they use it among themselves. There are some examples of use of similar discourse in the student-to-student dialogues captured on tape. More examples would be needed to claim that students had adopted the discourse that emphasised how one got one's answers rather than what the answers

are. However, analysis of one pair provides a framework for further analysis of such dialogues. The discussion analysed here involved a discussion of the mathematical equation for the probability of drawing a red card from a pack. This discussion included claims, warrants, challenges, counter claims, and agreements. The identifiers in this analysis combine the naming of arguments used by Krummheuer (1995) with those related to the relationship of members of the pair (see Irwin, 1997; Piaget 1965).

S2 I think I know how to work it out … And 10 (places a 10 on top of another 10). CLAIM
S1 So see, there's 2, 4, 6, 8, 10, 12, 14, 16, 18, 20 22, 26, so there's 26 packs. WARRANT
S2 No, cause it's 2 … DISAGREEMENT
S1 26 cards. RESPONSE TO DISAGREEMENT, RETURN TO WARRANT
S2 No wait, 2 x 13 and that's 26. The 2 stands for there's two suits and there's 13 altogether. Thirteen in the red cards. See. CLAIM, WARRANT, REQUEST FOR AGREEMENT
S1 Yip and that equals 26 … 36. ACKNOWLEDGMENT, CLAIM, REVISED CLAIM
S2 26. DISAGREEMENT
S1 I mean 26. ACKNOWLEDGMENT
S2 No, we've got to make times 13 to make 13. DISAGREEMENT, CLAIM
S1 Thirteen is an odd number – you can't divide 13. (unintelligible) Only an even number like 12 or 18. CLAIM
S2 Yeah, but we … (PARTIAL – not scored)
S1 See, 13 x 2 equals 26 and 26 is an even number. REPEAT CLAIM
S2 Oh yeah… that is right. ACKNOWLEDGMENT
S1 And then the 2 the 13 in it [referring to two suits of 13 cards]. CLAIM
S2 And there's 26. CLAIM
S1 That two suits and 13, 13 … 13, 13 is … (partial CLAIM – not scored)
S2 No, it's 13 altogether in red. DISAGREEMENT
S1/S2 Thirteen altogether in red. (The students say it in unison as they write it.) AGREEMENT

This passage has some of the characteristics of joint problem solving between peers who want to understand each other but lacks other aspects (for example, see Irwin, 1997; Piaget, 1965). They are actively engaged in making sense of the mathematics of their task. S1 makes more claims than her partner (S1: 5 claims, S2: 3 claims); both students offer two warrants; S2 disagrees three times while S1 does not disagree but asks for agreement once. They have the characteristics of a pair that listen to and respect each other's contributions, but they are not equal in giving and asking for explanations. As is often the case with classroom tasks, these students appear to see their job as getting an answer, writing it, and moving on to the next question on the sheet.

In contrast, in Ms Regal's class, students were not seen to engage in discussion with one another in any attempt to explain or convince. Students at the same table worked on similar problems and talked to themselves but did not mimic the form of mathematical questioning and explaining modelled in the strategy questioning in the numeracy assessments.

Use of mathematical vocabulary

An emphasis of the Khisty and Chval (2002) paper is the fact that the teacher in that study, who was so successful in raising the achievement of her students who had English as an additional language, introduced mathematical terms early and expected her students to use these terms. Thus, very early in the year, she introduced the term "inverse" and told students of its importance in relating operations like multiplication and division. This is only one of many words that allow students to think about mathematical relationships in ways that are useful for further mathematics. There appears to be relatively little emphasis in NDP materials on the use

of advanced mathematical language or the mathematics register. The advice given in *Mathematics in the New Zealand Curriculum* (Ministry of Education, 1992) may compound difficulty with use of the mathematical register as it instructs teachers to use everyday language with their students before introducing mathematical language. Use of children's language versus the use of mathematical language is an issue in classrooms where students do not have a firm grasp of English.

Some of the students in this class did have difficulty with terms used in mathematics. The first author observed two classes in which students were struggling to sort out the meaning of "likely" and "unlikely". The teacher gave additional instruction on the meaning of these terms, and students helped each other with them. It was apparent from one of the interviews that the English word for half was unfamiliar or forgotten, but in this setting, the teacher appropriately acknowledged his confusion but did not instruct. There were occasions in class where she and the class used the colloquial terms "sum" for equation and "timesing" for multiplying. All of these language difficulties and uses are understandable. A teacher wants to be understood and it is easiest to use the common language of students, such as "timesing". The use of students' terms follows the rules of conversation (Sacks, 1992) if not those of the mathematics register. One recommendation that could be made on the basis of this brief analysis of teacher's and Pasifika students' language is that there is a place in the NDP for emphasis on using mathematical terms that will enable students to master more complex mathematics rather than relying on the students' everyday language.

Relation of language to success in numeracy

We have inadequate evidence to show a direct relationship between appropriate mathematical language and progress, but it is of interest that this class was relatively successful by the criteria of the NDP. At the start of the year, 14, or 51%, of the 27 year 5 and year 6 students in this class were assessed as part–whole thinkers. By the end of the year, 21 students, or 78%, were using part–whole thinking on at least one of the strategy scales. These figures are based on a student's top stage in any of the three strategy scales, as previous evidence shows that students perform differently to the challenges of these different scales (Irwin & Niederer, 2002). The closest comparison to this is the percentages for Pasifika students in the national sample of Pasifika students in 2004. That sample showed 54% of year 5 Pasifika students and 65% of year 6 Pasifika students to be working at the part–whole level in addition at the end of the year.

This move to part–whole thinking is seen as the crucial step for any students, and one in which Pasifika students lag behind other ethnic or linguistic groups. Ms Connor's class appears to be a successful class by numeracy criteria. The teacher's and students' language may be a contributing factor to this success.

Summary and Suggestions

The focus teacher, Ms Connor, uses many aspects of discourse in her teaching that are similar to the language of the NDP interviews in her teaching. Her emphasis is on the students' thinking and learning, not on telling students the answers. She displayed very little "teacher lust", the natural enemy of enquiry teaching. The students appear to respond by using similar discourse structures themselves. The contrast between her discourse and that of Ms Regal highlights the different way in which she promotes mathematical thinking in her classroom. Although the language reported here is only a small snapshot of the language in either class, it

was analysed intensively. We believe that Ms Connor presents the NDP in the manner intended by its authors and the Ministry of Education.

Our one suggestion for improving the use of the NDP with Pasifika students would be to put more emphasis on the use of the mathematics register, both terms and the discourse of premise and consequence, rather than colloquial terms and conversational conventions. As said in the introduction, this is one of the factors that might affect the achievement of Pasifika students that teachers can influence. The paper by Khisty and Chval (2002) provides an example of the way in which the correct use of advanced mathematical terms helped the development of mathematical thinking in a group of students who had English as an additional language and had not been doing well at school.

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