A SOCIOLINGUISTIC PERSPECTIVE IN THE STUDY OF THE SOCIAL CONTEXT IN MATHEMATICS EDUCATION

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This paper illustrates the use of the Functional Theory of Language as presented by Halliday to compare the interaction between students and teachers in a mathematics classrooms as a function of gender and social class. The constructs of field and tenor presented by Halliday are used to compare the observation from two classrooms from a high social class boys' school and a low social class girls' school. Conclusions form the data as well as methodological implications are discussed.

During the past few years research in mathematics education witnessed significant shifts in the issues being investigated, the methods used and theoretical prespectives adopted (Atweh, Carrs, & Kanes, 1993). While process-product research, that aimed at developing generalised theories for the prediction and controlling of student learning, traditionally dominated research in mathematics education, more recently there was a significant increase in research that aimed to illuminate and explain the process of education in its diverse contexts. Researchers in mathematics education were quick to diversify their methodologies and perspectives in generating and analysing data to achieve these new concerns. One such new approach was sociolinguistics (Florio-Ruane, 1987, Evertson & Smylie, 1987). This paper illustrates the use of a particular sociolinguistic approach to understanding the mathematics classroom and to analysing student-teacher interactions.

SOCIOLINGUISTICS IN MATHEMATICS EDUCATION

Ellerton and Clarkson (1992) reviewed several studies conducted in Australasia, between 1988 and 1992, that were primarily concerned with language aspects of mathematics teaching and learning. The overriding concern of these studies was how the mode and form of language can be manipulated to increase students' learning of mathematics. The authors presented a model, suggested by Ellerton (1989) specifying sociolinguistics and psycholinguistics approaches as two aspects of the 'interface between language, mathematics and mathematics learning' (1992, p. 156). However, none of the studies reviewed followed either approach. Reviewing the research on the social context of mathematics education in the same period, Atweh, Cooper and Kanes (1992) identified four studies that used Wittensteinian approach that employed sociolinguistic concepts to explain aspects of the social context of mathematics education. These papers argued that mathematical concepts have no essential meaning outside the social context in which they operate. Hence, learning mathematics is mediated through language rather than through thinking.

To illustrate the use of sociolinguistics in mathematics education, this paper will adopt the Functional Theory of language as exhibited in the writings of Michael Halliday (1973,1974, 1978; Halliday & Hassan, 1989). According to this view "language is the main channel through which the patterns of living are transmitted to [the individual], through which he[/she] learns to act as a member of 'society'-in and through the various social groups, the family, the neighbourhood, and so on- and to adopt its 'culture', its methods of thought and action, its beliefs and its values" (1974, page 4). The child is "... socialised into the value systems and behaviour patterns of the culture through the use of language at the same time that he[/she] is learning it" (page 21).

To understand the language and its use one also needs to study its context. Halliday points out that the origin of the word context is CON-TEXT ie. 'with the text'. Con-text is an accompanying text that adds to the understanding of the intended text. Halliday presents a model with three components to analyse the context of a text. The three components of context are:

1 Field: refers to the institutional setting in which a piece of language occurs and embraces not only the subject matter but the whole activity of the speaker and participant in a setting[and we might add: 'and of other participants]...
2. Mode: refers to the channel of communication adopted, not only between spoken and written words but much more detailed choices [and we might add:' and other choices relating to the role of language in the situation] ...
3. Tenor: refers to the relationship between participants, ... not merely variations in formality ... but ... such questions as the permanence or otherwise of the relationship and the degree of emotional charge in it. (page 34) [brackets in original]

THE STUDY

This paper reports on analysis of a segment of the data collected as part of a long term project on the Social Context of mathematics education at the Centre of Mathematics and Science Education (Atweh & Cooper, 1989, 1991). The overall aim of the project was to study the nature and form of mathematics knowledge as presented in the school and to study the perceptions of students and teachers of the nature of mathematics and its relevance in the life of students. Of particular interest to the project was the investigation of the effect of gender and socio-economic background of students on the perceptions and how these perception affect the classroom interactions. The project consisted of a series of field studies (Popkewitz & Tabachnick, 1981). This paper is mainly concerned with the first study, carried out in 1989 in two private schools in Brisbane. The schools were selected to maximise the socio-economic and gender differences. The first school, Northside High, was an all girls' school from a low socio-economic part of the city, and the second school, Cityview, was an all boy's school that attracted most of its students from professional families. Both participating schools followed the same work program in mathematics, used the same textbook and were teaching the same chapter while participating in this study.

Grade nine (second year in the secondary school system in Queensland) was observed for the duration of one topic from the syllabus, about two weeks. Classroom interactions were recorded using a special classroom observation instrument developed by the authors (Atweh & Cooper, 1992). Class proceedings were tape recorded and later transcribed. Other sources of data collected were school publications and interviewees with principals, subject masters, cooperating teachers, and selected students. This paper is mainly concerned with classroom observations. In the following discussion the classroom observations will be analysed using the first and last components of Halliday's model.

RESULTS

The Field of Discourse

The field in both instances observed were mathematics classes where interaction oscillated between doing mathematics (ie mathematics as the primary field of discourse) and talking about doing mathematics (ie. mathematics as the subject matter or the second-order field of discourse) (Halliday, 1978). Both classes observed were teaching the same content in algebra: review of the Cartesian plane and plotting of linear functions. Both classes were very teacher dominated. However, a closer look at the classroom interactions reveals many differences in the hidden curriculum being constructed.

Ivor, the teacher at the boys school, presented rigorous definitions of the concept of a function in the following words:

Domain: numbers where we get the x(independent variables)
Range : numbers where we get the y (dependent variables)
Set of ordered pairs is a function iff for a value of x there is one and only one value of y.

He then presented a more algorithmic version of the definition that may be used to determine if a relation is a function. Dealing with the same concept, Jeff, the teacher at the girls school, introduced the definition through the algorithm. In all his definitions, Jeff attempted to give many examples and counter examples of a concept and assisted students to generalise a pattern. He used these pattern as definitions. It was obvious that the two classes experienced mathematics as a formal system in different ways.

Further, Ivor stressed the convention nature of mathematics. In dealing with the co-ordinate system, after quickly reviewing what the students have done last year on plotting points, he asked the students why is it essential that the x- co-ordinate always comes first. Jeff's explanation of the same rule was " [since we say] x,y,z then x comes in first therefore the x-co-ordinate comes first". Once again the "justification" was presented an a rule of thumb to remember the order rather than a "formal" justification.

Another difference noticed in both classes related to application of the mathematics discussed to real world problems. At the end of his first class with the students, Ivor reviewed the work that the students have done on the pendulum in the science class. As homework he asked the students to perform an experiment on varying the length of the pendulum and measuring its period. Students were asked to tabulate the results and graph them. Similarly, to justify the need in mathematics to differentiate between functions and non functions he used an example from science.

This morning in science we were talking about classification of plants. We said that some [types] have some properties, and [other types] have other properties. Here we have a relations: we have functions and non functions. It is just a classification. You may wonder why do we need to classify anything. It helps us to analyse a particular area.

Jeff, on the other hand made no attempt to link the content studied to other subjects or to real world applications.

Hence, although the two classes are dealing with the same mathematics, and in rather similar way, the hidden curricula in both classes was quite different. In one class mathematics was presented as a formal system, while in the second class mathematics was based on generalisations and rule of thumb; one class stressed the reasons behind conventions while the second class presented conventions as "rules of the game"; finally, one class presented mathematics as meaningful activity related to the real world, while the second class presented mathematics as a set of rules to manipulate symbols. The question was not which mathematics is more valid or valuable, or which teaching style was more effective or relevant. Ivor presented mathematics that he perceived would be needed for higher studies in mathematics and Jeff is teaching mathematics that was "not very useful" for these students. Ivor was enculturating his students into the culture of "formal mathematics" and Jeff was enculturating his students into a culture of "following rules".

The Tenor of Discourse:

Ivor believed that most of his students are university bound. Being independent in assessing one learning and achievement was seen as a useful behaviour to nurture for higher education settings. This was reflected in the way that Ivor interacted with his students. While working on the exercises from the textbook, Ivor expected his students to check their own work. He was quite sarcastic when a student asked him to check their work for them. "You have the answers in the back of the book, check it your self." "Your are a big boy now, you do not need me to check your work." Jeff has a different attitude towards students work. He corrected the mistakes that students were making by discussing them on the blackboard. He provided further examples and repeated the rules "for those who are still experiencing problems". The two messages from the two classes were clearly different. While one class expected and challenged students to engage themselves in checking their progress, the other provided an atmosphere of support and readily available assistance to deal with their difficulties.

Another difference in the tone of both classes was the general atmosphere in the classroom. Ivor conducted a class that gave a feeling of a battle ground, a field of contestation between students and teachers. Several times in the lesson students complained "I do not understand this" and were not hesitant to say "I still do not understand". When the Ivor was discussing the classification of relations into functions and non functions, a student complained "What is the practical use of studying that." When the teacher said "It is a mathematical use and solely that" the student insisted "What use is that?" Also noticeable in the class was the use of sarcasm by the teacher. Sarcasm was used in several places in the classroom: when students asked an apparently silly question, or when a student was not paying attention or disrupting the class. The affect of sarcasm could only be understood in context of the situation in which it arose. The teacher's sarcastic comments were not taken by the students as a put down. The atmosphere of contestation, either in challenging the teacher for more information or in forms of disruptive behaviour, did not subside in the class as a result of these comments. Rather these comments were understood as demands for attention, but also as means of establishing an atmosphere of equality and reciprocal privilege with the teacher. Students responded to these comments by laughing or by sarcasm of their own:

The teacher: Have you finished your chewing gum yet? You can go and put it in the bin. Is it one of the school rules around here that your are not allowed to have chewing gum in the school?

The offending student: I have not read it anywhere

Another student: (Opens a book at random) Rule thirteen, Alcohol and chewing gums are allowed.... (Class bursts in laughing).

Jeff had a very different way of interacting with his student. He was very formal and serious with his students. He was firm in his expectation of and demand for attention and co-operation yet he was noticeably polite in his interactions with the girls. To get the attention of some students he would say "Excuse me there, are you all right". He consistently called girls by their first names, and never reprimanded anyone for a wrong answer. The messages from the two classes are quite different. They are consistent with stereotypes that boys are independent, tough and are rebellious and girls are dependent, fragile and obedient.

A further interesting difference between the two classes was seen in positioning of the human agency with respect to mathematics knowledge. The following discussion relates to the two segments of interaction from both classes listed in the Appendix.

One feature of the mathematical language in the girls' class is that it was not "exact" or "complete". Secondly, every sentence has one personal pronoun. This sample is quite representative of the style of talk that Jeff engaged in with his students. No sentence has a mathematical term as its subject. Mathematical knowledge was not presented as an abstract content separate from what people do. It should be pointed out, however, that peoples' action that constitute mathematics was not presented as the everyday life action; that is, not "meaningful" action. Lastly, the role of the first person pronoun was interesting. The "we" indicates a group ownership of the example and the procedures to be adopted. However, the two references to "I said to you" refer to a rule that students are to follow, but the rule is given without an explanation. This is not the only such construct that appears in Jeff's talk. When students were connecting plotted points, obtained from a quadratic equation, by straight lines, the teacher said.

Now some of you have joined the points with a ruler to get a V shape. Now there is nothing wrong with that but I want to tell you that from now on when you get something like that do not join them with a straight line. Join them with a smooth curve.

No additional information was given.

It is worthwhile noting the proper and rigorous mathematical language that Ivor was using. Also, in contrast to Jeff, Ivor used much less first and second person constructs, thus giving the impression that mathematics was an objective discipline that had "truths" of its own independently of us. It should also be recalled, that these truths were presented as meaningful since they were useful in everyday life and agreed upon to facilitate communication.

Conclusions

The comparison of the context of discourse of mathematics in the two classrooms studied showed that even though the teachers and students were engaged in working from the same textbook, the actualised curriculum was quite different in both classes. One classroom was developing mathematics as a highly formal field of study, stressing mathematical structures, concepts and language, the second class was developing mathematics as a set of skills or rules. The first class stressed meanings and reasons while the second class stressed generalisations of pattern from within mathematics itself. Further students in one class were encouraged to be self reliant in checking their progress and to be participants in their development of mathematics ideas, while the second class, indirectly encouraged the dependence on the teacher as a source of knowledge and assessment. Using the sociolinguistic terms adopted in this analysis the two classes differed in the field and tenor of discourse.

Secondly, these alternative constructions of the context do not have the same social value. One construction was perceived as appropriate for students intending to go into higher education and useful for making scientific and business decisions while the second was perceived as appropriate for the "less able" students and appropriate for consumer transactions. If discourse in the area of language and mathematics is to provide useful information about the development of mathematical understanding in children, then, inevitably, it has to address the question of value.

Thirdly, the Social Context Project was conceived from within the social critical sociology perspective. It adopted the ethnographic methods of data collection, including interviews and classroom observations. The social critical sociology provided the conceptual tools for analysing the data, but not the practical tools to deal with the huge amount of data gathered. The Functional Theory of language is a sociolinguistic theory that provides a view of language use that is sympathetic with the social context views adopted by this project, and has provided a framework for dealing with the classroom observations. This analysis illustrated the benefit obtained of using both perspective in an attempt to make sense of the data. Naturally not all the constructs of that theory were used. Our interest in looking at the role of language in this project is a social context one and not a pure linguistic one. Other investigation into the role of language of mathematics and in constructing understanding may make use of other aspects of this theory.

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APPENDIX

Jeff's Class

[Jeff is teaching the plotting of inequalities. He has taken an example of y<x. Without any justification, he says "How about doing this one first y=x? He then proceeds to plot the linear function and chooses several points on the plane some on the line and some are not]

So we have a Cartesian plane with points everywhere. Now, [there are] some important things to remember. What I have done here is the equation y = x. And, we [have] seen the quadrant and [have] see[n] whether the points lie on the line. [This was] a quick revision of the things we have done these two weeks. So how is this going to help us in graphing inequation? Most of you are thinking this. Very simply if we have this (points to y=x) and this (points to y<x) they are identical. The only difference is this here: the sign (points to the = and the < signs). And if you remember the time when we were solving inequations, I said to you to solve them exactly the same way as you would with equations. So if we had, 5 = x+4 and worked that out, and then we had 5<x+4, I said to you to solve these exactly the same way as [you would] with the equal sign. So that is exactly the same procedure we are going to do in graphing inequations. We are going to graph them the same way as we graph a normal equation. There are a couple of exemptions. When we have a symbol < or > we are going to use a dotted line. (teacher writes):

Summary:
1) if symbol < or > use a dotted line
2) only time to use heavy line is if we
have <=
or >=

Ivor's class.

T: Take out your homework form last night. You were asked to do nos. 6,7,8,9,12,14,16. You are asked to, first of all to state the domain for each of those graphs that were drawn, then you were asked to state the range, and then you were asked to state if it was a function or not. First of all .... Andrew! I told you to sit down five minutes ago, (Andrew complains that he was picking up paper from the floor.) You do a good job. You should be a cleaning lady. (Class laughs).

Right, (Teacher writes on board and reads out loud):

Domain: numbers where we get the x(independent variables)
Range : numbers where we get the y (dependent variables)

(Teacher asks for help from students to name variables)

Then we end up with [a] set of order[ed] pairs. (writes (x,y)) ordered pairs x,y. (says and writes)

Set of ordered pairs is a function iff (what ...)for a value of x there is one (not one, but one) and only one value of y.

It is important to say one and only one. We can not have zero. There must be a value, for every x there must be a value of y, and there must be only one value of y.

Let us look at number 6. What is the domain, in other words from what numbers do we choose the x values? There is only one x value, what is that? The domain is -2. That's it. What is the range?

(Teacher writes) Domain (-2)

S: -2,-1,0,1,2,3

(Teacher writes) Range (-2,-1,0,1,2,3)

For that one value of x, how many values are there of y?

S: 6

T: Is there one and only one value of y for a given value of x? No. there are six in this case. Then it is not a function. Precisely.