An Investigation of Literacy in the Teaching and Learning of Mathematics in Secondary Schools Serving Low Socio-economic Status Communities

Bob Perry
University of Western Sydney
<b.perry@uws.edu.au>

Lloyd Dawe
University of Sydney
<l.dawe@edfac.usyd.edu.au>

Peter Howard
Australian Catholic University
<p.howard@mary.acu.edu.au>

Bob Dengate
Charles Sturt University
<bdengate@csu.edu.au>

This paper reports on an investigation, commissioned by the Disadvantaged Schools Program (DSP) of the NSW Department of Education and Training, to identify the best ways to provide support for mathematics teachers in DSP secondary schools, so that they can assist their students to meet the literacy demands of mathematics. Case studies in four markedly different secondary schools were carried out by the authors. Through these, the role of literacy in mathematics learning, teaching and assessment, as perceived by the mathematics teachers and students, has been considered.

In recent years, literacy has been a significant issue in Australian education and has been taken very seriously by both State and Commonwealth governments. In New South Wales, a range of initiatives, under the banner of the State Literacy Strategy (e.g., NSW Department of Education and Training, 1999b), has been implemented in an attempt to increase the literacy levels of students generally, and to address the specific literacy needs of individual subjects and Key Learning Areas (KLAs) (e.g., NSW Department of Education and Training, 1999c). Individual schools have developed and implemented their own literacy plans in the light of these wider initiatives.

The Disadvantaged Schools Program (DSP) is a specific focus program within NSW Department of Education and Training schools which "supports schools serving students from communities with the highest concentrations of families from low socio-economic status (SES) backgrounds. It is an equity program focused on improving student literacy outcomes" (NSW Department of Education and Training, 1999a, p. 2). The DSP complements the implementation of the NSW State Literacy Strategy in its 478 schools through the provision of extra funding and support. The study which is the subject of this paper was commissioned by the DSP specifically to identify the best ways in which support could be provided to mathematics teachers in secondary schools serving low socio-economic communities.

Literature Review

As part of the commissioned project, an extensive literature review on the role of language in mathematics teaching and learning was conducted (Dawe, Dengate, Howard, & Perry , 1999). An overview is presented here.

The body of research into mathematics and language has expanded rapidly over the last ten years (e.g., Davis & Hunting, 1990; Ellerton & Clements, 1996; Mousley & Sullivan, 1996). A constant theme of this research is that language factors have a strong influence on the learning of mathematics and that there are strong links between the development of literacy capabilities and mathematics learning. At the secondary level, there has been a lack of awareness on the part of mathematics teachers to take seriously the literacy demands of their subject, and the literacy needs of their students (Dawe et al., 1999). Much of the research (e.g., Sullivan, 1999)

has considered the levels and nature of classroom communication in mathematics classrooms and has led to equivocal conclusions about the value of such accepted practices as cooperative group learning (e.g., Gooding, 1994; Stacey, 1992). Other research has considered specifically the nature of 'good questions' or 'rich tasks' and their relationship to students' learning of mathematics (e.g., Sullivan & Clarke, 1991; Sullivan & Lilburn, 1997). In at least one Australian state, the notion of rich tasks has been developed as the centrepiece of systemic educational reform across the entire curriculum (Education Queensland, 2000).

Other issues of concern in the relationship between literacy and mathematics teaching and learning include the particular issues of socio-economic, cultural and language backgrounds. For example, Zevenbergen (1994) has argued that mathematics can, and often does, serve as a social filter and that 'middle class' and 'working class' schools were likely to imbue different discourses of interaction and success through the nature of their mathematics lessons. Similarly, cultural backgrounds can provide differences in the ways in which students view school mathematics and its importance in society (e.g., Barton, 1993; Stigler and Hiebert, 1999; Stigler & Stevenson, 1994). There are challenges raised by non-English speaking background students in mathematics classes but there are also opportunities provided by these students. No longer is bilingualism seen as a disadvantage to learning (e.g., Clarkson, 1991) but there are issues which affect students who are not fully competent in one or both of their languages.

The schools in which the case studies were conducted were selected because they represented secondary schools in the DSP. That is, they were schools serving low socio-economic status communities. Students in these schools do not perform as well as those in schools in middle or higher socio-economic status communities on statewide measures of literacy achievement nor on similar measures of mathematical achievement. The links between low socio-economic status and achievement in literacy and mathematics are well established (Hilton, 1998; Peterson, 1997). Moreover, it has been argued that the socio-economic status variable is so powerful that it may not be possible to change the nature and directions of these links without changing the nature of the socio-economic mix of the student body (Thrupp, 1998). The DSP in NSW is founded on the philosophy that it can make a difference. This study is part of the action arising from the philosophy.

Method

In early 1999, the four authors of this paper met with officers from the DSP to discuss the issues involved in linking literacy and mathematics. In particular, the DSP wanted to ascertain how it could help mathematics teachers in its secondary schools to address the needs of their students to meet the literacy demands of their mathematics learning. It was determined to use a case study methodology in four secondary schools in NSW. These schools were chosen to represent different DSP contexts.

- *School A.* This secondary school is located in a northwest NSW town. The school's student population is 250 and there are 31 teachers at the school, with three in the mathematics faculty.
- *School B.* This school is located in central west NSW. The school's student population is approximately 880 students. There are seven full-time mathematics teachers.

- *School C.* This school is located on the south coast of NSW in the suburbs of a major city. The school's student population is 640, with many students being the third generation of their family to attend the school. There are six full-time mathematics teachers.
- *School D.* This school is located in the western suburbs of Sydney. The school's student population is about 1150 and there are students from 62 different nationality backgrounds enrolled. There are nine full-time mathematics teachers.

The research questions for this study were devised by the researchers in conjunction with the relevant DSP officers. They were quite extensive. Those reported in this paper are as follows.

1. What are the expressed views of secondary mathematics teachers (in DSP schools) on:
   a) the role of literacy in their teaching of Years 7-12;
   b) the role of literacy in their students' learning in Years 7-12 and
   c) the literacy demands of external examinations and the impact on classroom instruction.
2. What are the expressed views of secondary mathematics students (in DSP schools) on:
   a) the role of literacy in their learning of mathematics in Years 7-12;
   b) the role of literacy in how they are taught mathematics in Years 7-12 and
   c) their ability to comprehend questions in either school-based or external assessment tasks.

In each of the schools, one of the authors met with the mathematics faculty, other teachers and students. Data were gathered using focus group interviews which were tape recorded and transcribed. Some mathematics lessons in each school were observed.

Results

Teachers Views on the Role of Literacy in their Teaching of Mathematics

In all of the case study schools, innovative and creative practices relevant to the role of literacy in mathematics teaching had been introduced. Activities had been developed including the students presenting a written account of certain curriculum topics, peer assessment of oral reports, the negotiation of meaning via the modification and reconstruction of students' own language, genuine reciprocal communication between teachers and students about the purpose, process and product of mathematical activities, underlining of key words in written explanations and definitions, packs of mathematical activities which take literacy issues into account, and close partnerships between mathematics teachers and support teachers. This indicated that the State Literacy Strategy has had an effect in these schools and that many of the teachers were aware of the importance of literacy issues in mathematics. As one teacher put it, "literacy in maths is critical. It is survival. If we, as teachers, don't do it we are going to have more children who see no purpose in school mathematics". Another teacher commented that "you have to teach the children to read. You have to be explicit".

It was a commonly expressed feeling that there were a lot more literacy issues to be dealt with in the lower level mathematics courses than in the higher level courses, in both the junior and senior years. One teacher suggested that:

within my Mathematics in Practice[1] course there is a lot more literacy and discussion about the meaning of certain words and the context of maths as opposed to other classes. But if you are doing 2 unit calculus, there is not as much literacy.

While there was a recognition of the need to be cognisant of literacy issues in mathematics teaching, not all teachers were prepared to allow that their classrooms should include opportunities for all of the areas of reading, writing, speaking and listening. One teacher suggested:

in my classroom, I try to minimise one of those-I'm a traditional maths teacher. ... I am perfectly happy to ask for specific feedback from kids by way of a statement that they might have made but I generally have not encouraged open discussion.

Teachers' Views on the Role of Literacy in their Students' Learning of Mathematics

The teachers interviewed stated that it was very important for the students to understand the mathematical terminology being introduced and to use it correctly. Students making the transition from 'conversational' to 'mathematical' language was a prime goal in the junior years of School D. In later years in this school, the correct use of terminology, logical connectives, prepositions and other difficult aspects of the mathematics register for second language learners were addressed through a whole-school literacy policy. The interviewed teachers suggested that these had a direct influence on students' 'deep' versus 'surface' learning.

In all the schools, the teachers were aware that many of the students in the lower level classes had poor literacy skills. They said that this fact was sometimes used as an excuse for the lower mathematical achievements of these students. In School A, some teachers saw that that this was an inevitable consequence of the students' backgrounds:

the children just don't have literacy backgrounds to cope with the literacy needs of English and maths. Listening skills are not needed in the home as much as they were. Literacy in maths has not been a focus in the past. You look at the textbook and there is no emphasis.

Teachers' Views of the Literacy Demands of Examinations

Responses to this question varied between the schools. In School C, for example, there was no doubt in the minds of the mathematics staff that what is in past examinations affects what they teach and how they teach it. "Basically, the HSC determines what and how we teach, whether we like it or not". However, the teachers did not seem to think that these examinations necessarily presented literacy demands which were beyond or significantly different in nature to those literacy demands occurring in the everyday classroom. Hence, they did not see anything special, beyond the usual examination techniques and strategies which needed to be taught to their students.

In School D, the reading requirements of the external examination for Year 10 mathematics attracted a great deal of criticism for not providing an opportunity for students to really show what they could do. One teacher put it this way:

Sometimes it just becomes who can answer ... who can fill in an exam paper better than others ... you might have the best maths ability but you don't know how to fill in the paper properly ... there are just too many different styles of questions ... I think they found that a bit of a shock.

[1] The least academic of the mathematics courses in Years 11 and 12 in NSW in 1999.

The difficulties with examinations was reiterated by a teacher from School A who pointed out that changes in the mathematics curriculum had resulted in a greater teaching focus on problem solving and that this had resulted in different types of examination questions which demanded increased literacy abilities in the students. He suggested that "open ended exams have placed an increased emphasis on students' reading and literacy skills".

Students' Views on the Role of Literacy in their Learning of Mathematics

Some of the students interviewed identified stress, anxiety, frustration and annoyance as emotions that affected them in their learning of mathematics. Some felt sorry for those peers who could not do the work. While many students referred to the importance of listening and talking about mathematics in the classroom, they also saw reading, particularly reading the textbook, as a vital source of explanations and model answers. One student commented: "In textbooks, right, we actually learn it off more ... In class, if you don't get a concept, it is easier to go back to the textbook and look through the examples because it is much clearer". Writing out examples was seen as less important, although, in the students' eyes, it did help to consolidate the skills and routines. Writing in terms of explanation or as a reasoned argument (as in an essay) was not seen as a mathematical activity by these students.

A contrasting view was evident in School C where many of the students, while acknowledging that the textbook was an important source of information, highlighted a dilemma for them which arose when the teacher used different language and/or processes from those in the textbook to explain particular mathematical ideas. This has the potential to leave the learners in a confused state. Students in all the case study schools were adamant that they "generally find the way the teacher explains it easier to understand than that in the textbook ... they're actually talking. They're actually relating to you".

Students do not seem to talk to each other much, either in or beyond the classroom, about the mathematics that they are doing. Outside the classroom, "there are more exciting things" to talk about. Inside the classroom, "if you have a problem you might ask for help from someone sitting beside you". This seems to help because it "reassures you about what you are doing". When asked to whom they would go if they wanted help with a mathematics problem, students were adamant that they would go to a peer in the same class - "a reliable someone next to you".

Students' Views on the Role of Literacy in how they are Taught Mathematics

Students are aware of the huge amount of curriculum content through which the teacher must move. However, this does not stop them being critical of the pace at which they are expected to learn their mathematics, as shown by this comment from a School A student: "They will teach one topic and then move onto the next but I haven't understood the first one". The students know there is so much to cover that "some teachers just go on and on and on without giving us a chance to take a breath. Often when the teacher is talking too much it just goes in one ear and out the other".

In School B, extensive writing occurs, but most of it appears to be of a copying nature: "If she writes it, we write it, is our rule". In another class, an insightful view of oral interaction was given by one student: "The teacher asks a lot of questions when the work is really important". However, in this same school, senior students could not comprehend that the literacy demands of mathematics needed to be considered and suggested that language and mathematics were totally disparate: "English is in this box, maths in that box".

Another group of students felt that teachers were too harsh in quelling talking in class. "Teachers don't understand that you can talk and do work. Yes, you can talk and actually solve a problem." Not surprisingly, while teachers did not necessarily disagree with this sentiment, they were adamant that much of the talking in classrooms had little to do with the tasks which had been set for students to do. The observations of lessons undertaken by the researchers indicated that talk in classrooms certainly covers both of these aspects.

Students from another of the schools also had something to say about the talk that goes on in the classroom and the effect it had on their learning.

> Good teachers change the language and the ways that they explain it to the children. It is better if the teachers talk personally rather than 'up the front'. A good teacher helps you. They are strict but not grouchy, they let you have a bit of freedom and they let you talk. I would like to talk more in mathematics. Sometimes your friends can explain it better than the teacher-and that's when you are told to stop talking!

Some students, especially in School D, were keen to know more than the teachers seemed prepared to share. One commented: "Some teachers teach you exactly what you need to know in a syllabus, but they don't teach you anything more advanced, harder to do". However, this was not a universal comment: "For me, I couldn't keep up with the teacher. He was going too fast. He would explain once but not again, so you'd have to keep moving on. It was just too difficult for me".

Students' Views on their Ability to Comprehend Questions in either School-based or External Assessment Tasks

Many of the issues which have been identified above also have some pertinence for the literacy demands of assessment in mathematics. Key among these are the issues surrounding differences between the mode and density of language used when a teacher is explaining an idea and when it is used in a problem during an assessment exercise. One group of senior students was asked to consider a particular question from the 1996 HSC examination for the *Mathematics in Society* course. They wondered about the relevance of the question to them as students, even though it did make an attempt to situate the question in a real-life situation. The students also commented on the extraneous information through which they needed to wade before they came to what they were supposed to do. The use of what the students saw as 'difficult' language rather than more 'common' language was also criticised, especially when the latter could maintain the mathematical integrity of the question. In some cases, the students felt that too much information is given in assessment questions or the information is given in too many different forms, resulting in confusion. They cited the common occurrence of a drawing, a description and a diagrammatic representation of some trigonometric problems all being given and were adamant that: "Sometimes you are better off with just the triangle".

Discussion and Conclusions

The results shared above are not restricted to DSP schools (e.g., Ellerton & Clements, 1996; Miller et al., 1999). They highlight that both teachers and students in the four schools are aware of the importance of literacy issues in the learning of mathematics but do not necessarily know how to deal with them in the context of their mathematics lessons. However, they are trying, with many teachers using a wide range of teaching strategies to provide opportunities for students to deal with the literacy demands of mathematics. On the other hand, some teachers have yet to take seriously their role in the helping students meet these demands.

Direct instruction of content, followed by discussion, consolidation and practice is commonplace. Much less common are strategies such as practical work, problem solving, investigation using open-ended questions and cooperative group work. The role of writing in learning mathematics does not feature prominently in the work of teachers or syllabus and textbook authors. However, the expectations of the new Stage 5 and 6 mathematics syllabuses[1] - that the students will be able to express themselves in both speech and writing - may hasten the addressing of this.

Teachers need to engage with their students and provide structure through associated prompts and questioning. They need to use explicitly the students' mental imagery and their experiences to represent mathematical information in a wide variety of ways. Issues which arise from the different social and cultural backgrounds of the students need to be addressed. These issues do affect learning preferences and aspirations (Zevenbergen, 1994) and must be addressed in the context of mathematics learning. It is difficult to see how much progress can be made if, as one teacher from School C commented: "Another problem here is that 'it is seen to be cool not to be doing well'".

The impact of the DSP initiatives in the area of literacy in mathematics teaching and learning are beginning to bear fruit. Mathematics teachers have been seen as the most resistant group in secondary schools when it comes to consideration of the literacy demands of their subject. However, progress is obviously being made. The day-to-day routines of mathematics teachers serving in DSP schools are demanding and difficult. The issue of time is a major concern to many of these teachers, so the integration of literacy into content is critical - it cannot be seen as an 'add-on', or it will simply not be done. The leadership and enthusiasm of Head Teachers, Mathematics is critical. They can lead their colleagues through the development of specific teaching resources and approaches and can help them gain ownership of the strategies, with the result that literacy can be integrated into the content in such a way that the literacy demands of mathematics learning and teaching are met naturally. This is certainly the aim of the schools involved in this study and of the DSP as everyone involved moves towards the continual improvement of the mathematics education of all students.

References

Barton, B. (1993). Contemplating cultural contexts. In B. Atweh, C. Kanes, M. Carss, & G. Booker (Eds.), *Contexts in mathematics education.* Proceedings of the 16th annual conference of the Mathematics Education Research Group of Australasia (pp. 339-346). Brisbane: MERGA.

Clarkson, P. (1991). *Bilingualism and mathematics learning.* Geelong, Vic: Deakin University Press.

Davis, G. & Hunting, R. (1990). *Language issues in learning and teaching mathematics.* Melbourne: La Trobe University.

Dawe, L., Dengate, B., Howard, P., & Perry, B. (1999). *"We taught them but did they learn?" Research report of the investigation of literacy in the teaching and learning of mathematics in secondary schools.* Sydney: NSW Department of Education and Training.

Education Queensland (2000). *Queensland state education: The new basics project.* [On-line]. Available: http://education.qld.gov.au/corporate/framework/.

Ellerton, N. F. & Clements, M. A. (1996). Researching language factors in mathematics education: The Australasian contribution. In P. Sullivan, K. Owens, & B. Atweh (Eds.), *Research in mathematics education in Australasia 1992-1995* (pp. 191-235). Sydney: MERGA.

Gooding, A. (1994). Recognition of effective group discussion. In G. Bell, B. Wright., N. Leeson, & J. Geake (Eds.), *Challenges in mathematics education: Constraints on construction?* Proceedings of the 17th annual conference of the Mathematics Education Research Group of Australasia (pp. 295-303). Lismore, NSW: MERGA.

Hilton, M. (1998). Raising literacy standards: The true story. *English in Education, 32*(3), 4-16.

[1] Available at www.boardofstudies.nsw.edu.au.

Miller, B., Perry, B., Howard, P., Farmer, P., Long, M., & Roffe, S. (1999). The language of mathematics: Contextualisation or confusion? *Literacy Learning: Secondary Thoughts, 7*(2), 10-18.

Mousley, J. & Sullivan, P. (1996). Natural communication in mathematics classrooms: What does it look like? In P. C. Clarkson (Ed.), *Technology in mathematics education* (pp. 398-405). Melbourne: Mathematics Education Research Group of Australasia.

NSW Department of Education and Training (1998). *State literacy strategy: Implementation guide for schools.* Sydney: Author.

NSW Department of Education and Training (1999a). *Disadvantaged schools program: Operational guidelines 99.* Sydney: Author.

NSW Department of Education and Training (1999b). *Literacy strategy evaluation 1997 and 1998.* Sydney: Author.

NSW Department of Education and Training (1999c). *Teaching literacy in mathematics in Year 7.* Sydney: Author.

Peterson, M. E. H. (1997). *Low-SES literacy backgrounds: Effects on formal schooling.* (ERIC Document Reproduction Service No. ED 408 559).

Stacey, K. (1992). Mathematical problem solving in groups: Are two heads better than one? *Journal of Mathematical Behaviour, 11,* 261-275.

Stigler, J. & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom.* New York: The Free Press.

Stigler, J. W. & Stevenson, H. W. (1994). *The learning gap: Why our schools are failing and what we can learn from Japanese and Chinese education.* New York: Simon and Schuster.

Sullivan, P. (1999). Seeking a rationale for particular classroom tasks and activity. In J. M. Truran & K. M. Truran (Eds.), *Making the difference.* Proceedings of the 22nd annual conference of the Mathematics Education Research Group of Australasia (pp. 15-28). Adelaide: MERGA.

Sullivan, P. & Clarke, D. (1991). *Communication in the classroom: The importance of good questioning.* Geelong, Vic: Deakin University Press.

Sullivan, P. & Lilburn, P. (1997). *Open-ended maths activities: Using good questions to enhance learning.* Melbourne: Oxford University Press.

Thrupp, M. (1998). The art of the possible: Organizing and managing high and low socioeconomic schools. *Journal of Educational Policy, 13*(2), 197-219.

Zevenbergen, R. (1994). Psychologising educational difference. In G. Bell, B. Wright., N. Leeson, & J. Geake (Eds.), *Challenges in mathematics education: Constraints on construction?* Proceedings of the 17th annual conference of the Mathematics Education Research Group of Australasia (pp. 717-724). Lismore, NSW: MERGA.[1]

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