Language Factors that affect Mathematics Teaching and Learning of Pasifika Students

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This study investigated the language issues for senior Pasifika mathematics students in one school in the Manukau region Using the experiences of the Pasifika teacher/researchers, a test was constructed to investigate likely language difficulties Some interviews were conducted about the test Initial perceptions that vocabulary was the main problem were not borne out in the first test, although the interviews indicated that the language issues were interwoven There was some evidence for differences between Tongan and Samoan students, and between those who knew their Pasifika languages well and those who did not

Students' ability to articulate their strategies, discuss ideas and concepts critically, and communicate mathematical meaning has continued to be a more central focus in mathematics, and mathematics education Teaching pedagogies that are required to successfully achieve these purposes have put pressure on students who do not have English as their first language

The steady increase in bilingual learners is a reality of New Zealand classrooms, particularly in the Manukau Region In many of these classrooms there are students with different levels of competency in the language of instruction, and few teachers are able to speak to these students in their mother tongue The teaching and learning of mathematics in these schools in a language that is not the pupils' main language places additional and complex demands on teachers and learners

This study is part of a broader investigation of the nature of language factors that might affect the learning of mathematics for students for whom English is an Additional Language (EAL) (Neville-Barton & Barton, 2004) This part of the research focuses on Pasifika students at senior level, using the experiences of the Pasifika researchers

A brief outline of the theoretical and methodological approach adopted in this study will be provided Research data from questionnaires and interview will also be presented and summarised

Theoretical Background

Pasifika students are confronted with, and have to deal with a range of linguistic difficulties when learning mathematics One of these difficulties arises when their first language does not have the vocabulary to express the mathematical ideas that they learn in the classroom Mathematics vocabulary includes words that are specific to mathematics, such as divisor, denominator, quotient, and coefficient These words like many others are new to Pasifika students and there is no translation for them in the Pasifika languages Through "transliteration" English words are phonetically translated into Pasifika languages This has been the most common and convenient way of creating equivalent words from English (Taumoefolau, 2004) However, Fasi (1999) in his comprehensive study of the affects of bilingualism on Tongan students' mathematical achievement argued that the absence of many Westernized concepts in the social, and cultural lives of Tongan people, means that finding Tongan words for mathematical terms and concepts is a complicated task Concepts such as "absolute value", "simultaneous equations", "standard deviation", for example, have no equivalent functions in the activities of the Tongan people Dale and Cuevas (1987) noted that the task of learning the use of mathematical words must be done within particular mathematical contexts and it is not enough to learn lists of stand alone words Because Pasifika students have to learn mathematics through translation of English words it is a difficult task to contextualize their learning of mathematical words

Ellerton and Clarkson (1996) discussed how more difficult aspects of mathematics vocabulary involve the many ways in which the same mathematics operation can be signaled Other authors also commented on how multiple meanings of familiar words cause reading problems in mathematics (Dale & Cuevas, 1987; Mousley & Marks, 1991) Fasi (1999) found that words with multiple meanings in mathematical contexts become sources of confusion for Tongan students For instance, the Tonganized word “sikuea” (square) takes on various mathematical connotations –for example, an area, a number, or a numerical property

In addition to isolated vocabulary items, the mathematics register uses its special vocabulary to create complex strings of words or phrases (Halliday, 1978) In these phrases, often two or more mathematical concepts combine to form a new concept, compounding the task of comprehending the words (Mousley & Marks, 1991) Phrases such as ‘least multiple’, ‘three times as long’, ‘twice as much’, are examples that can be used to illustrate the complexity of mathematical terms Fasi (1999) commented on how teachers in Tonga find it difficult to distinguish between the meaning of non equivalent terms such as “very likely”, “probable”, and “almost certain” when expressed through Tongan language

Mathematical word problems provide some of the more cogent examples of mathematics discourse features at work Processing sentences in such a linguistically dense context, coupled with the logical nature of many mathematics problems, requires the reader to rely on the sentence to convey clear and unambiguous meaning (Halliday, 1978; Dale & Cuevas, 1987) Students’ ability to read in the language of instruction is vital to their performance in most academic disciplines If a students’ aim is to achieve success in mathematics, but she or he is continually hampered by reading problems, frustration and lessening of self-expectation is likely to occur The way students read the systematical structure of sentences, relational statements, order of sentences and logical connections have all been identified as potentially hindering conceptual understanding (Dale & Cuevas, 1987; Mousley & Marks, 1991; Galligan, 1997) Dawe’s (1983) study of second language students showed that the correct use of logical connectors was the one factor that differentiated those students who could reason mathematically in English from those who could not This was supported by Mousley and Marks (1991) who made the following comment with regard to students from low socio-economic background;

> Logical connectives are commonly misunderstood by students from lower socio-economic classes, those not so familiar with the ‘secondary school’ language of argument, justification and context specific materials (p 62)

Dawe (1983) and Clarkson (1992) both found that switching languages was a common practice of bilingual students with whom they worked, particularly when the perceived difficulty of the task increased Code-switching entails switching by the teachers and/or learners between the language of instruction and the learners’ main language (Clarkson & Dawe, 1994; Adler, 1998; Fasi, 1999; Setati & Adler, 2001) It might involve a word, a phrase, a sentence, or several sentences Setati (1998) found approaches to teaching mathematics in which bilingual students were encouraged to construct their own mathematical understanding, encouraged them and their teachers to use code-switching in a range of different situations Setati and Elder (2001) in their study noted that some teachers claimed that they had to use the first language to teach in some occasions because their students did not understand the mathematical terms or the concepts

The Study

All the four teachers who participated in this study were from the Pacific Islands Two female teachers came from Samoa, and the other two teachers were both native to Tonga All of them had completed most of their formal school education in Samoa, or Tonga before moving to New Zealand to complete their senior secondary, and university education

The two classes studied were both Year 12 classes from a High School that is situated in the Manukau region, which has the highest percentage of Pasifika peoples in New Zealand All 42 students were non-European and had different levels of competency in their first language Most of the students came from homes where the first language was not English The interview data showed that the majority of these homes were involved in community and church activities that use their mother tongue as the language of communication

In Phase 1 of the study, the team leader visited the two classes on a weekly basis for two terms Together with class teachers, he looked closely at individual students' work as they learned mathematics in the classroom Conversations were carefully observed with a focus on noting what languages the students and their teachers used the most, who they talked to, when they used English, and when they choose to use their mother tongue

This information, and discussions amongst the researchers about their own experiences, led to the construction of the questionnaire It was aimed at testing students' knowledge of vocabulary used within a word problem situation Test instructions were written in English, and either Tongan or Samoan Students were also asked how they felt about their level of understanding of English in mathematical learning Phase two of the project was the administration of this questionnaire to both classes A main result from the first questionnaire was that students have difficulty solving mathematical word problems

An interview schedule was designed to gather more information on what language students' used most often when they were at home, school and in the wider community It also included questions about the difficulties they have when they work on word problems Sixteen students drawn from volunteers from both classes were interviewed Two were interviewed individually, and the other 14 in pairs

Results and Discussions

Phase 1: Classroom Observation

Discussing mathematics was not a normal classroom practice for these two classes There was no use of: group investigation, problem solving, group discussions or hands on type activities Students were expected to work quietly and individually Students were exposed to limited language forms: the classroom displayed little mathematical language, and the classroom seating organization did not promote the possibility of inter-student communication

In both classes, code switching was a common practice between students with the same mother tongue Students tended to use mostly their first language in their personal conversations and also in mathematical conversations when these occurred In most cases, this happened immediately after the teachers' instructions for the whole class On many occasions, the Samoan teacher switched from English to Samoan when she moved around to help individual students in order to explain and clarify the mathematical concepts A group of Samoan students in her class always conversed in Samoan among themselves, and their expectation of the teacher was to reply in Samoan when they ask questions The teacher's view on code switching was:

> In the classroom when I am explaining a concept to a Samoan student I switch from English to Samoan and vice versa With students who speak very little English I don't even have to think about the language I use – that being Samoan However, with Samoan students who are fluent English speakers I explain it in English and then in Samoan My thinking behind this is to speak in the language the child is most comfortable in to aid understanding

Phase 2: The Questionnaire

An increasing body of research indicates that one of the crucial roles of teachers of mathematics is to assist learners to acquire, in both receptive and expressive modes, the formal language of mathematics (Ellerton & Clakson, 1996) Without a personally constructed knowledge base of mathematics vocabulary, the task of reading a mathematics textbook, interpreting a teachers' instructional commentary, solving a word problem, or communicating one's own knowledge about mathematics to others becomes extremely difficult for students The first questionnaire was divided into the following four different sections: Mathematical Instructions, Mathematical Vocabulary; Mathematical Language and Word Problems

Self-Reported Competency in English The responses show that over two thirds of these students feel that they have no, or only a little difficulty with reading mathematics textbooks, handouts and test questions

Instructions and Mathematical Vocabulary We tested students understanding of the following six instructional words: solve, evaluate, simplify, factorise, expand and rearrange Different mathematical solutions together with the instructional words were given, and students were asked to choose the word that best describes the given mathematical working

It was expected that the students would not have a good enough understanding to make the match However, a surprising feature of the results was that the students did better than what we anticipated, with the overall results indicating satisfactory understanding of terms except for "evaluate" There were two questions that were given to test their understanding of "evaluate", one with a function and the other with an equation More students got the right answer when they were given an equation then when they were given a function More students mistakenly chose 'rearrange' as their answer when a function was given There was a common confusion between 'factorise' and simplify as the procedure showed a simpler equation after the factorisation process The other common mistake was with the word 'solve' in which students seem to choose solve as the answer for the working that end with a number value

Students recognized the expanding procedure when two brackets were given, but did not do well when there was only one bracket This is evidence of restricted meanings where new vocabulary is associated with the exact context in which it is learnt and not the more general concept

Word Problems and Mathematical Language Word problems proved difficult for these students, even when the working was provided The results for two multiple-choice questions are given in Tables 1 and 2

Table 1
Summary of results for Question 4a

Sione's mother, Ana, is six years older than Sione's uncle, Tevita Tevita will be 60 years old in two years time Ana's age, a, is:

	a = 60 + 6 - 2	*a = 60 – 6-2*	*a = 60 + 6 + 2*	*a = 60 – 6 +2*
Percentage of Students	45	0	23	33

Table 2
Summary of Results for Question 4b

A number n is the product of itself minus 6 and half of itself

	n = (n–6) + n/2	*n* = (n-6)n/2	*n* = (n-6)/2	*n* = n/2 - 6
Percentage of students	13	31	46	10

Although it is made up of one sentence, it was difficult for students to formulate a formula for the 'number' n The complexity of working with a variable and the meaning of 'product' together with the reference to the number 'itself' all contributed to the difficulty

An example of a problem illustrating the students' difficulty in interpreting and making sense is the following:

A Wall is 2m high at one end, 3m high at the other end, and has a length of 6m Draw the wall in the space below The area of the wall is: (i) A = 15m square meters (ii) 30m square meters (iii) A = 30 square meters (iv) 15 square meters

This required the students to draw a diagram that represented a simple composite shape The problem was poorly done, only 16 % completed it successfully Although the students could follow a procedure for drawing a wall, they lacked the ability to sensibly interpret the situation, and apply their knowledge to the problem context Their interpretation of the length of the wall in most cases did not link to the idea that it is most likely to be associated with a level floor or level ceiling Hence, their drawing showed two sloping lines between the two walls This exasperated their attempts to find the area This highlights that students must have enough experience with mathematics texts to identify various contexts in which everyday background knowledge could be applied

Comparison between L1 and EAL Students The 42 students in the study fall into two major groups: those born and educated partly in Tonga or Samoa, and those born and brought up in New Zealand Both groups are similar in some ways and very different in others The exposure they have to their parents' culture and languages varies considerably A comparison between Pasifika students who claimed that English is their first language (L1) and those who claimed that their mother tongue is their first language (EAL) reveals some interesting results Table 4 shows that students whose first language is a Pasifika language perform better overall than those who speak English as their first language

Table 3
A comparison of Performance on Instructional Words

	Percentage of L1 students with correct answer	Percentage of EAL with correct answer
Evaluate	15	35
Expand	53	91
Simplify	61	56
Solve	61	69
Factorise	46	78
Rearrange	61	69

Table 4
A Comparison of Performance on Mathematical Vocabulary

	Percentage L1 students with correct answer	Percentage of EAL students with correct answer
Quadratic	0	100
Cyclic	7	52
Exponential	7	43
Exponent	46	70
Co-efficient	61	87
Numerator	85	74
Denominator	92	78
Linear	98	96

The results were more mixed for the mathematical vocabulary, as shown in Table 4 All students showed a good understanding of numerator and denominator, with L1 students being better, but the EAL students understood the other terms better It appears as though the L1 students had trouble with all algebraic terminology

Phase 3: The interview

The first part of the interview revealed that most of them were bilingual However, their fluency on both languages was lower than what could be expected of Year 12 students The second part provided some results about students understanding of the mathematical meaning of the words used in the word problems Students were verbally fluent when asked to read a question aloud, although some could not verbalise symbols When they were asked specifically whether there was anything that they could not understand, they all responded positively about their general understanding However, being able to read the text or the problem does not guarantee understanding of the concept, process, or ability to solve the problem

Many of the difficulties students encountered with mathematical word problems were those concerned with relational statements Relational statements include ‘transitive inferencing’ problems, for example, “Viliami’s salary is less than twice Ana’s salary” This was problematic for all except for one student When students were asked to write “twice as Ana’s salary” (given that ‘Ana’s salary is A), students found it difficult to use variables until the interviewer gave them hints Common mistakes were AA and A^2 even when some could say that twice means “double”

Some students didn't know the word for the greater than sign ">" One student referred to it as "over", and some missed it out completely when they were asked to read the question aloud "Less than" was often mistaken with take away Four students wrote V – 2A instead of V < 2A

Conclusion

This study has made us aware of the differences between the language that bilingual students use in the classroom and the language that they use in their home and social environment The translation of the questions used in the research questionnaires reveals that Pasifika languages do have mathematical discourse, and it is different from the general language that community uses on their normal communications Both Tongan and Samoan languages have mathematical discourses but they have not yet been fully developed Thus bilingual students are unfamiliar with many mathematical terms, and phrases both in the translation and in English The complexities of mathematical sentences have been shown to provide extra challenges for these students learning These factors play a major role in the language features that impede Pasifika students' learning of mathematics

Students in this research performed well on questions involving instructional vocabulary However, when they were given word problems that required them to read a question or statement, think, analyze, and carry out appropriate computations, most students did not have the appropriate problem solving strategies Students need to be strong in both their general and mathematical language These combine to provide the comprehension skills needed to successfully make sense of and solve mathematical word problems If their mathematical background is poor at this level, it does not matter what language we test them on their mother tongue or in English – either the relational understanding has not been laid down or there is a combination of poor English ability and undeveloped mathematical discourse in their mother tongue It is our belief that it is more a problem with their mathematics rather than the language of instruction, but this needs more investigation

There is enough evidence in this study to support the theory that students who use their mother tongue while learning in English perform better than those who don't Teachers should be aware that code switching is a common practice for the bilingual students in these classrooms Further research is needed to investigate how bilingual students who have a preference for their non-English language can develop their mother tongue so that it will match new concepts being taught in the classroom

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