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AUSTRALIAN VIETNAMESE STUDENTS LEARNING MATHEMATICS: HIGH ABILITY BILINGUALS AND THEIR USE OF THEIR LANGUAGES*

ABSTRACT. Bilingual students have, at times, been thought to be at a disadvantage in learning mathematics because of an assumed interference between their two languages. Earlier research, confirmed again in this study, shows that this is a naive view to take. Although some bilingual students do have a harder time, others seem to be at an advantage. This study explores the use that bilingual students who are succeeding in mathematics make of their two languages. These students seem to have better metalinguistics skills that allow them to self-correct when solving problems, and are perhaps more confident in their approach to solving difficult problems. It also appears that students in this study switched between languages in early years of schooling, but only used English by the time they were completing elementary school.

KEY WORDS: bilinguals, immigrant students, language switching, mathematics and language, novel problems, Vietnamese students

Australia is a land of many languages. Although the official and dominant language is Australian English many other languages are used as citizens go about their daily lives. Australia's migrant intake has remained reasonably stable at about 100 000 per year for the last 30 years. However, during this time there was a marked change in the origins of most immigrants. In the late 1960s, well over half our immigrants were from English-speaking countries. During the 1970s and 1980s, that figure fell to below 25%. Hence, by the late 1980s, 14% of Australia's then 16 million people spoke a language other than English in their homes. This percentage continues to increase. Such a rapid change in the immigration profile led to a major increase in the number of Non-English-Speaking Background (NESB) students. Hence in most urban schools in Australia's major cities, many languages are represented. It is common for a class grouping of 25 to 30 children to come from families representing five or six countries. In some parts of Sydney and Melbourne, this representation can rise to 10 or more countries.

Until recently, there was little recognition by teachers in Australian schools that language can influence the learning of mathematics, and even

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less thought given to the notion that a student's non-English language may be important. If there was such recognition then the naive position was taken that the first language was somewhat irrelevant, although competence in the language of learning (here, English) was to some extent important. Most teachers, the majority of whom are monolingual English-speakers, were also not aware that their bilingual students would switch languages while thinking about their class work. If some teachers did concede this was happening, they did so only for cultural or language-based work, not for mathematics. Such recognition was normally justified on social grounds, such as that it gives access and status to each student's particular cultural background. Of course when teaching children from such diverse backgrounds, with the pressures of 'keeping the classroom going', it is not always easy to see such issues as important. It was within this scenario of teaching mathematics in a multilingual context that the present project was born.

1. Research on the influence of language on mathematics learning and teaching

During the last 20 years, the links between language competence and mathematics learning have become an important area of research (Ellerton and Clarkson, 1996; Ellerton et al., 2000; Durkin and Shire, 1991). In particular, issues of learning mathematics in multilingual contexts have attracted attention (e.g., Adler, 1995; Barton et al., 1998; Barwell, 2003; Gorgorio and Planas, 2001; Roberts, 1998; Setati and Adler, 2000). Until the early 1970s, it was often assumed that being bilingual offered no advantage for school learning. Indeed it was seen as a hindrance: bilingual students who attempted to use both their languages in the classroom were believed to become confused. This naive position was often the basis for opposing any attempt at using the ability to communicate in two languages in the classroom. Starting in the 1960s, data began to accumulate that was at variance with this view (e.g. Peal and Lambert, 1962; Skutnabb-Kangas and Toukomaa, 1976). These data led to a refinement of the notion of bilingualism, to include, for example, balanced bilingualism, and additive or subtractive learning environments (Lambert, 1977; Cummins, 1979, 1991). In the 1980s, research on the cognitive effects of bilingualism on mathematical reasoning and problem-solving was started (Dawe, 1983; Clarkson, 1992). The theoretical basis for the Dawe (1983) and Clarkson (1992) research drew on the work of Cummins (1979, 1984; Cummins and Swain, 1986). Cummins hypothesised that the level of competence a bilingual child develops in each language is directly related to academic performance. There are two conditions. Firstly, both languages must have enough social value

and worth to flourish as languages of thought and expression. Secondly, both languages must meet some minimum threshold of competence before the cognitive advantages of being bilingual are realised. When these conditions are met, the evidence that bilingual young people, relative to monolingual controls, show greater cognitive flexibility, creativity, divergent thought and improved problem-solving abilities, is very persuasive (Baker, 1996, pp. 145–161; Lambert, 1990, pp. 210–213). The Dawe and Clarkson studies provided benchmark evidence from widely different cultures and languages that bilingual students highly competent in both their languages were mathematically superior to their monolingual peers, and to bilingual peers dominant in one language, when the effects of intelligence, schooling, socio-economic status, age and sex were controlled. Students weak in both languages were also mathematically weak. These results, confirmed by research in the United States with Spanish/English bilinguals (Secada, 1992, p. 638), support the theoretical idea of thresholds.

Part of an explanation for the above findings concerns language-switching, an issue taken up in the study described below. Results from the foreign language teaching and learning literature give useful background for this study. Cohen (1995) obtained data about verbal thought patterns from both foreign language and English as a Second Language (ESL) students. His results suggested that, of the factors which determine the language(s) multi/bi lingual people think in at a given moment, some were accidental, while others are more reasoned or calculated. Kern (1994) carried out an empirical study on the language of thought for the specific task of comprehending foreign language texts. He explored the actual uses for translation into L1 (the learner's first learnt language) in the language learning process. His study provides a number of insights as to why second language learners use their L1:

- By so doing, the learner processes thought more easily, since using L1 facilitates semantic processing.
- If learners process the input exclusively in L2, they run the risk of losing their train of thought as soon as the chunks are long or syntactically complex, since they are harder to hold in short term memory.
- Indulging in mental translation during L2 aural comprehension or reading is likely to allow the learner to represent in a familiar, memory-efficient form, portions of the oral or written text that exceed cognitive limits. Translation then serves as a means of maintaining concentration long enough for meaning to be integrated and assimilated.
- By thinking in L1, the concepts are likely to come alive because the learner's network of associations is usually richer than in the second language.

- Thinking in L1 converts the input into more familiar terms, enhancing learners' confidence in their ability to understand. This may reduce feelings of insecurity.
- Learners may revert to L1 because they find it helps them in clarifying syntactic roles, verifying a verb tense, or checking for comprehension.

However, Kern claimed that translation does not always work to the learner's advantage. There were a number of possibilities, among them:

- Attempts at translation may be inaccurate.
- Strategies that are too reliant on 'word by word' translation may not adequately provide for integration of meaning.
- Learners who are translating during language processing may be attending to L2 forms only very briefly and reserving the bulk of meaning processing for the L1 mental representations.
- There is a danger then that the learner will focus primarily on transformed L1 representations rather than on the original L2 forms.

Some results from two studies of language switching in mathematics classrooms that were part of Spanish immersion programs in the United States were also of interest to the present study. Cohen (1994) reported that most children responded to both numerical and verbal problems presented in Spanish by favouring English in their cognitive processing, and were also observed to be doing so in normal class work. They would read a problem in Spanish, but would generally shift to English as soon as they had some conceptual difficulty. Such difficulties might include comprehension of a complicated problem, clarification of embedded concepts, understanding instructions, encountering difficult vocabulary, or affective responses. Cuevas et al. (1995, personal communication[1]) also reported a study that examined the choice of language students made when responding to mathematical tasks. They found a strong relationship between the language the teacher predominantly used in the classroom (English), and the language chosen by the students to answer questions and solve mathematical tasks. Only 11 of the 77 students indicated they used both their languages, and even then English predominated when discussing mathematics. For problem solving tasks, most students selected the English version of the task. However, a small number of students indicated they used both Spanish and English to read and understand these tasks. Among the reasons they gave was "If I do not understand one language I read the other to see if I understand the problem" (Cuevas et al., 1995, p. 14).

I now turn to the additional issue of metalinguistic awareness. This concept includes the ability to reflect and manipulate the structural features of language, treating language itself as an object of thought. It is just one

aspect of the wider role that metacognition plays in problem-solving behaviour (Schoenfeld, 1987, 1992; Goos and Galbraith, 1996). Studies in "natural" translation, that is, translation by a naive bilingual child without any special training in translation, have shown that the main factor contributing to successful translation appears to be metalinguistic awareness (Malakoff, 1992). Part of this awareness is dealing with key words. Bialystok found in her studies of 5–9 year-old bilinguals that they were able to separate out individual words from meaningful sentences, often in the context of non-essential information, in order to focus on what the question was asking (Bialystok, 1987, p. 138). Such metalinguistic abilities, linked to metacognition, seem to be important ingredients in mathematics performance. It was therefore useful in this study of bilingual students to focus on both language-switching and metalinguistic awareness.

2. Outline of the paper

The project will be described in two sections. Section 3 will summarize previously published papers on whether or not bilingual students in the study used both their languages when processing mathematical problems, and whether their competence with their languages influenced performance. Section 4 will delve into how a particular group of these students made use of their languages. For clarity and convenience, both sections will start with an outline of the relevant methodology, although, clearly, in implementing the project, there was no such distinction.

3. Bilingual competence and mathematical performance

3.1. *Subjects*

Schools in Melbourne, Australia were chosen using three criteria:

1. the school had a positive commitment to bilingual students and the use of their L1;
2. the school was easily accessible for the researcher;
3. there was a reasonable number of Vietnamese students in year 4 (most students in year 4 are 9 years old).

Vietnamese was chosen as the target language partly because of the ready access to available schools, but also because of the rapidly increasing number of Vietnamese students in Melbourne. Six schools were found that met these criteria. In each school, many other immigrant communities were

also represented. The schools were all in the inner or middle suburbia, with the majority of families living generally in working class or lower middle class areas. The year 4 students included in the study had completed all their schooling in Australia. We targeted students who the schools advised were NESB Vietnamese. An examination of the student data reduced the sample to a group of 85, since some students had only one parent born in Vietnam, and some students spoke Chinese rather than Vietnamese as their L1.

3.2. *Instruments*

Three different mathematics tests were used in the study. The first was termed the *Mathematics Symbols Test*. This test consisted of items 1 to 10 and 21 to 30 of the ACER Operations Test (Australian Council for Educational Research, 1978). All items were composed of numbers and/or mathematical symbols. For all items there was a stem followed by 4 or 5 alternative answers.

The *Mathematics Word Problem Test* consisted of 10 items drawn from the ACER PATMATH series 1 (Australian Council for Educational Research, 1988). The items covered number, measurement and spatial topics. The format of each item was a stem with 4 or 5 alternatives.

The *Mathematics Novel Problem Test* was made up of a variety of 'open' items of the type that Sullivan and Clarke (1992) have explored and was composed of 10 items with an extended answer format. Two scores were computed from this test. The first was the 'Novel Raw Score' which was calculated by allocating one mark for each item where there was at least one correct answer given (remembering that multiple answers could be given for the items). A second score was termed the 'Novel Score' calculated by giving one mark for each correct answer to a maximum of 3 marks per item. Incorrect answers when multiple answers were given were ignored.

The Byte Score was derived from the Mathematics Symbols Test (described above) and was used as a measure of cognitive development (Cornish and Wines, 1977). In the analysis, this score was used in much the same way as IQ scores are often used as in an earlier study (Clarkson and Galbraith, 1992).

Students completed three additional sheets, termed the *Language Information Sheets*. These were attached to the back of each mathematics test. This instrument was essentially composed of 6 columns. In the first column the item numbers of the attached test were listed. The other five columns were headed 'used all English' through 'used part English and part Vietnamese' to 'used all Vietnamese'. After completing a test students were asked as a group to turn to the Language Information Sheet. After some

discussion with the class about how monolingual people can only think in one language but people who know two languages might think in one or the other, or sometimes switch backwards and forward between them, students were asked to look at this sheet. The supervisor then said that he would like to know about the language(s) that students thought in when completing the test. The students were asked to look back at item 1 and remember as best they could which language(s) they used to think about it. They were then asked to tick the appropriate column. After completing the second item as a group, the students were asked to work through the other items by themselves, each time looking back at the item before ticking a column. The supervisor then moved around the group (with the classroom teacher if available) handling any queries and ensuring that students were not confused. In each class, there were some students who needed further discussion about what to do, but all students completed the task adequately.

The *Language Use Survey* asked students where, with whom, and how often they used their L1 out of school.

For the *Vietnamese Language Competency Test*, two of the Vietnamese language teachers in the schools were asked to translate into Vietnamese a commonly used comprehension test (Mossenson et al., 1987). They also audiotaped the passage in Vietnamese. In the test situation, students were asked to complete one item at a time. While the students read the item, it was played on the audiotape. Subsequently, other teachers told us that this test was appropriate for the students we were targeting. The Vietnamese language teachers who taught the year 4 children rated them for reading, listening, writing and speaking abilities. Few differences were found between the students' test scores and the rating that teachers gave.

The *English Language Competency Test* was another of the written comprehension test from the same source as the Vietnamese test (Mossenson et al., 1987).

A variation of a technique used in an earlier study was used to partition students into relatively high competence in both languages, dominance in one language ('one dominant'), or relatively low competence in both languages (Clarkson, 1992). Based on their English Language Comprehension Test scores, students were designated as having relatively high, middle or low competence in English. Threshold scores for these levels were decided by examining the English comprehension scores obtained by the students in the same classes who were monolingual English speakers. The monolingual students' scores were rank ordered, and the two scores that divided this group into equal thirds were noted. These scores were then applied to the rank order of Vietnamese students' scores to divide this group into three sub-groups of unequal numbers.

The median score of the Vietnamese Language Comprehension Test scores was used to partition the students into relatively high or low competence sub-groups for Vietnamese competence. Students were then classified into one of six cells and designated as having relatively high/high competence in both languages, relatively low/low, or relatively one dominant if they were rated as highly competent in one language and low competence in the other. These three categories made up the *Language Competence Designation* of students. Clearly some students drop out of the sample using this technique. In this analysis they were students who were classified into the middle sub-group for English competence and low competence in Vietnamese. It was because of this drop out factor that the decision was taken to partition the students into two sub-groups based on their Vietnamese scores, rather than three sub groups as for English.

3.3. *Results*

The first notion to explore was whether the children used their two languages when attempting mathematical problems. An earlier analysis of the data obtained from the *Language Information Sheet* showed that between 40 and 50% of students did so for at least one item on each of the three different types of mathematics tests (Clarkson, 1996).

Another question concerns whether using Vietnamese in solving problems makes a difference to students' academic performance. Correlation coefficients were calculated between the different mathematics scores and the number of items for which students used some Vietnamese in their solution attempts. There were significant correlations of 0.4 for both the raw and novel scores for the Mathematics Novel Problem Test, but non-significant correlations for the Mathematical Word Problems Test and the Mathematical Symbols Test (significance was set at the 0.05 level for all correlation coefficients). When correlation coefficients were calculated between item difficulties for each test and the number of students who used Vietnamese to complete an item, there was a 0.7 significant correlation for the Mathematical Word Problems Test, but non-significant results for the others. The earlier analysis suggested that the use of L1 does have some type of impact, but this was not consistent across mathematical contexts.

Further analysis suggested that the differences between the means on the three mathematics tests for the Vietnamese students and their monolingual English speaking classmates, and between the Vietnamese students and all students who attended these schools were of little educational importance (Clarkson, 1997). However, it was a different story when consideration was given to the level of competence that the Vietnamese students had with their twin languages. To have some measure of the bilingual students'

language competencies, the Languages Competence Designation described earlier was used. Three analyses of covariance were computed to investigate the effect of the level of bilingual competence on the raw scores of the Mathematical Word Problems Test and the Mathematical Novel Problem Test, and on the 'Novel Score' on the latter test. In each analysis the Byte Score that was used as a measure of cognitive development was included as a co-variable. When the raw score of the Mathematical Word Problems Test was used as the dependent variable the model was clearly significant [$F(3, 59) = 12.44$: $p < 0.001$]. Similar results were found when the 'Novel Raw Score' was used as the dependent variable [$F(3, 60) = 6.36$: $p < 0.01$] and when the 'Novel Score' was used [$F(3, 60) = 4.24$: $p < 0.05$]. Each analysis showed that the students included as having high competence in both their languages outperformed the other two groups, although Scheffe tests in each case indicated that the differences between this group and the one dominant group were not statistically different. Both these groups, however, were significantly different to the students who were classified as having low competency in both their languages.

Overall, these results give an indication that students' language competencies have an important impact on their mathematical performances over a number of different contexts. Although the sample was small, and, unlike in earlier projects, a limited number of co-variables were included in the analysis of covariance models, these results are in line with Cummins' threshold hypotheses. They are also similar to previous results that both Clarkson and Dawe have found working with very different groups of students in other countries (Dawe, 1983; Clarkson, 1992).

4. Reasons for switching between languages

This section explores data from one-on-one interviews with students about their reasons for switching languages when solving mathematical problems.

4.1. *Subjects for interviews*

Since all interviews were conducted after the various class testing described above had been completed, we were able to select students who had indicated on the Language Information Sheets that they had used Vietnamese to complete some mathematical items. We were also guided by the teachers who identified fluent bilingual children from their classes. To refine the analysis, one particular group of students was targeted. They were members of the high/high cell of the Language Competence Designation.

This important group represents students who have outperformed others in mathematics, presumably at least in part because of their competency in both their languages. However, in carrying out the project in the short time available, students in this group were identified after the interviews. Hence interview data were collected from a range of students, including those whose responses we would later wish to target. Of the 85 Vietnamese students who participated in the study, eight students were classified as high/high. Four of these students were interviewed.

4.2. *Interviews*

The author was able to spend several days with the students in class, getting to know them and to be accepted before he conducted the class testing. He also carried out all the interviews. Thus the researcher had a good deal of information about the students' classrooms before the interviews began. Whenever possible, the classroom teacher or the specialist Vietnamese language teacher sat in on the interview. This occurred for about 30% of the time. These teachers only occasionally intervened during the interview, but their insights after each interview proved helpful.

The interviews took place in a quiet room away from the classroom. Each interview was simultaneously video and audio taped. Although the author had outlined the purpose of the interviews to each class after the testing phase of the project, this was again discussed with the student. In particular, the researcher emphasised that he would be asking students to discuss their thinking after they had solved some mathematical problems.

The student was then asked to solve three to four mathematics problems. Each problem was presented in English at the top of a single page with plenty of space for working. The student was asked to first read the problem aloud. The interviewer then checked that the student understood its context. This did not prove to be an issue for any student. They then worked without interference until they signaled they had finished. On completion, the videotape was placed in the video machine. The remote control was placed on the table between the interviewer and student so that either could control the video playback. The student was encouraged to do so at any time. To emphasise this, the student was asked to rewind the tape before the second segment of the interview began.

The interviewer began this second segment of the interview by asking the student to talk about their thinking from when they had read aloud the first problem. Both student and interviewer viewed the video of the student's attempts while the student described what was happening. The interviewer interjected with questions from time to time. At appropriate moments, the video was stopped and matters such as homework were discussed. This

second segment of the session was also videotaped in such a way that the student, interviewer and video machine playing back the student's initial attempts to solve the problems were all in view. Finally, after the student had left, the researcher discussed the student's responses with the teacher if he or she was present.

Gathered in this way, interview data was very dependent on verbal reporting. Arguments that support such approaches, while recognising their limitations, are synthesised by Goos and Galbraith (1996). It is acknowledged that various environmental influences such as stress, researcher's interventions and task demands can impact on both problem-solving behaviour and subsequent reporting. To minimise these influences, time was taken to familiarise the students with the procedures and equipment. The interview did not start until the interviewer was satisfied that each student was settled. No intervention took place during the student's attempted solution of a problem. The real-world context of each problem was discussed before the student started to ensure familiarity with the situation described. It is recognised that the data may be incomplete and that the subjects may not have reported all the relevant processes of interest. To minimise this effect, students were chosen who had the ability to report accurately and fully.

There are also questions of inconsistency, generalisation and researcher bias. Verbal reports may not correspond to what actually took place. To counter this problem, the researcher discussed such matters with the teacher (if he or she was present), immediately after the student interview, including, for example, whether they felt the student was being genuine. This discussion was audio-taped so that it was possible to reflect on it later. There was no indication that students were not being forthright and honest in their discussion during the interviews. With respect to generalisation, it is acknowledged that verbal methods are sensitive to individual differences. But these data as a whole enable a search for potential characteristic linguistic patterns that underlie the problem-solving process to be undertaken. As for researcher bias in the interpretation of the data, Goos and Galbraith (1996, p. 234) quote Ginsburg, who pointed out "in any form of research the significance of the data must always be judged relative to the researcher's explicit or implicit theories and assumptions". For this study, these assumptions have been outlined, at least to some degree.

4.3. *The interview problems*

As a result of a pilot study and after consultation with a number of teachers the following three items are examples of the seven that were used during the interviews.

1. Kim bought 3 chocolate bars at the shop. Two chocolate bars were 75 cents each. The other one was $ 1.00. How much did she pay?
2. Mary ran a race in 59 seconds. She walked the same distance, but was 12 seconds slower. What was Mary's walking time?
3. John and Mary measured a basketball court with the same ruler. John found that the court was 120 rulers long. Mary found that the court was 119 rulers long. How could this happen?

In general, at least one of the items that had specific answers like item 1 was chosen, as well as at least one of the novel questions such as item 3. The students had not often experienced novel questions that could have more than one correct answer and this added extra interest. The students found most of the seven items difficult but solvable, and hence this set of items appeared suitable for the purposes of this study.

4.4. *Results*

An analysis of the data from the Language Use Survey for the four students interviewed who had been classified as high/high showed that three of the students were born in Australia with the fourth immigrating when she was very young. Their parents were all born in Vietnam and all spoke Vietnamese and English. All students spoke Vietnamese as their main language at home and this was the language they would normally use with their parents. It was also the language their parents used in the home when speaking to each other. English was also used from time to time in the home. All four students attended special Vietnamese language classes out of school time. Although all students reported some encouragement to use and actually did use Vietnamese with friends and with relatives, only one student reported doing so to any great extent.

All students scored high marks on the Vietnamese Language Competency Test. The specialist language teachers in their schools also attested to their competence in Vietnamese. Interestingly, although all four students reported that they were highly competent at speaking Vietnamese, there was quite a variation in their self-ratings of reading, writing and understanding this language. All students were rated by their teachers as very good to excellent on their verbal and writing ability in English. They all scored either 17 or 18 out of 20 on the English Language Competency Test.

Although all teachers rated these four students as excellent to very good in mathematics this was not always borne out in their performances on the tests used in this project. Table I shows their scores and the number of items on each test for which they reported using Vietnamese. Clearly two students found the Mathematics Word Problem Test difficult, but not

TABLE I

Students' scores on three mathematics tests (possible maximum in brackets), and the frequency of items for which Vietnamese was used in the solution process[a]

	'Hien'		'Vinny'		'Son'		'Nhung'	
Students	Raw score	Use of L1	Raw score	Use of L1	Raw score	Use of L1	Raw score	Use of L1
Mathematics word problem test (10)	5	0	8	7	4	0	8	8
Mathematics novel problem test (10)	8	0	9	5	8	0	9	7
Mathematics Symbols Test (20)	13	0	19	13	10	0	16	10

[a]Student pseudonyms are used.

as difficult as many of their peers. Two of the students reported that they were never aware of using Vietnamese when solving the problems. The other two students suggested they were conscious of using Vietnamese frequently in these situations. The results in Table I are consistent with what these students had noted in the Language Use Survey.

In the data from the interviews, there clearly were some language issues that confronted the four students for one or more of the problems. Some of these were issues common to year 4 students, irrespective of whether they were monolingual or bilingual. For example, errors occur at times during the sub-process of reading the item. A number of times these four students did not read carefully all the critical aspects of the problem. When one student was asked to redo the chocolate problem during the interview he started by reading it aloud:

Student: Kim bought [omitting 3] chocolate bars at the shop. The [substituting 'the' for 'two'] chocolate bars were 75 cents each. . .
Researcher: Hang on. Could you read the first bit again?
Student: Two chocolate bars were 75 cents each and the other was. . .
Researcher: Now hang on, let's just think about that. How many chocolate bars is Kim buying?
Student: Student: 3. . .

This student has made two reading errors, each time leaving out key words for the overall meaning of the problem that led to his original attempt giving quite an erroneous answer. There were also times when the students showed an inadequate general comprehension of an item and hence did not focus on appropriate end points, either for the problem as a whole, or

for intermediate steps within the larger solution process. But sometimes the students self-corrected their initial misunderstanding. For the running problem, one student had taken 12 from 59, but then changed his mind:

Researcher: What sort of said this is a take away?
Student: Because of the 12 seconds slower.
Researcher: . . . Now you changed your mind. What made you change your mind?
Student: The 12 seconds slower is 12 seconds slower than 59.
Researcher: Yeah? So? What did that mean to you?
Student: That means that she took 12 seconds more than 59, not less than 59.

At other times, the size or presence of numbers became so important that it swamped other possibilities before they were even considered. Hence, for the basketball court problem, one student initially proceeded to add 120 and 119 because they were unsure of what to do.

Such reading and comprehension errors have been highlighted in the past using various error interview models including that of Newman[2] (Clarkson, 1991). Nevertheless, the impression was gained that the frequency of such errors for these four students was less than would be expected for year 4 students as a whole. More importantly, many of these errors were self-corrected, often during the initial solution attempt. These four students were also very competent with processing the number operations that were appropriate for the different problems. During the interviews with the students, once particular misconceptions were recognised, often during their initial attempts in segment one of the interview, all students went on to the processing of the mathematics with alacrity and confidence. One could speculate that this self-correction ability, which nearly always focused on the students ability to manipulate the language of the problem and not with arithmetical processes, was an outcome of the students' use of their metalinguaistic/metacognition abilities. Such a linkage for bilingual students was noted in the literature reviewed above (Bialystok, 1987).

In considering the students' specific use of their two languages, it will be recalled from Table I that two students indicated that, when completing the mathematical tests in class, they never used Vietnamese. The other two students indicated they did use Vietnamese reasonably often. These data were collected before students were interviewed. The interview results tended to be in line with the results of Table I, although they were not identical.

'Son' gave no indication that he ever used Vietnamese in thinking through the mathematical problems he was faced with during the interview

process, or at any other time in school mathematics. 'Son' did attend Vietnamese school on Saturdays and there was a specialist Vietnamese teacher at his school. Any help given for homework was completed in a mixture of English, when the helper was an older sibling, and Vietnamese when the helper was a parent. Interestingly 'Son' had some help in mathematics from a different quarter:

Student: Yes. Once my mum went to Vietnam and my dad, I went to a cousin's house to stay and their mum teach me how to do times and plus, that's how I remember.
Researcher: Now did they talk to you in English or Vietnamese?
Student: I had to write the numbers in Vietnamese and did that in Vietnamese and sometimes in English.
Researcher: When your Auntie was teaching you. . . .And she taught you how to multiply [in Vietnamese]?
Student: And plus and take away.

So this student has had an experience of learning some mathematics in both languages with an emphasis on his first language, apart from help with homework. He also reported that he was able to count up to at least a thousand in Vietnamese and it seems that his Vietnamese teacher at school occasionally asked his class to complete some mathematics in Vietnamese as well. But 'Son' remained adamant that all his mathematical processing was in English without offering any explanation why he never used Vietnamese. It seems it was just a non-issue for him, although it would appear that he had the learning experiences and examples from significant others to choose to use Vietnamese in these situations if he so desired.

For 'Hien', there was no indication from what was reported in Table I that she would make any use of Vietnamese in attempting the interview problems. However, this was not quite the case. At one point in the interview 'Hien' volunteered that she sometimes used Vietnamese:

Researcher: Do you do all of your work in English? Do you ever think in Vietnamese?
Student: Sometimes
Researcher: When would you use Vietnamese?
Student: Sometimes in maths. Not much.
Researcher: But why? When do you do it and why do you do it?
Student: I just read in Vietnamese when I don't understand it all
Researcher: It's only when they get really hard that you swap into Vietnamese?. . .
Student: Yes

As we worked through some of the problems that 'Hien' admitted she found quite hard, using Vietnamese was not a strategy she employed. One wonders, then, just how hard the problem would need to be before 'Hien' would switch. However, her assertion identifies one reason, perceived difficulty, why these competent students may well use the strategy of switching between their languages.

The other two students interviewed from this high/high group had indicated that they had used their first language at least sometimes when attempting some of the mathematical items in class. It was therefore no surprise to note that they also used Vietnamese in the interview situation, but the extent to which they did and why varied. For the chocolate problem 'Nhung' did not include in her calculations the price of the second chocolate bar for 75 cents. With some judicious questioning in the interview, during which she had to do some hard thinking, she spotted the mistake and completed a recalculation correctly with no further help. There was no indication of the use of Vietnamese during the initial attempt or when completing the extra work. However, for the running problem, in which she initially used subtraction, the operation was completed in Vietnamese. 'Nhung' then spotted, still during her initial attempt, that she should have added and redid the problem correctly. On reviewing this on video, 'Nhung' said she completed the second attempt "half and half", half in Vietnamese and half in English. This switching was prompted by the difficulty that she encountered in solving the problem. When it came to the basketball problem, 'Nhung' clearly said that the problem was reread and then thought about in Vietnamese. The written solution that 'Nhung' initially gave showed little understanding of the problem and there was little progress in her thinking during the interview. So after reminding 'Nhung' that she indicated on the Language Information Sheet the previous day that she at times had used Vietnamese to complete some items, I said:

Researcher: So it's really when you do not understand is when you swap back into Vietnamese. Other times you just work in English all of the time do you?
Student: No
Researcher: No?
Student: Sometimes it's easier in Vietnamese.
Researcher: It's easier in Vietnamese. So what sort of times would it be easier in Vietnamese?
Student: Doing fractions.
Researcher: Fraction. Did you say fractions? [student nods] Why would they be easier [to do in Vietnamese] do you think?
Student: Because the English way is harder than the Vietnamese way.

Researcher: Has someone shown you in Vietnamese how to work those out? [student nods] Who has shown you?
Student: My mum and my sister.

'Nhung' offered a number of reasons why she might use Vietnamese when attempting to solve mathematical problems. Clearly one reason was that she sometimes finds it easier. This may be because she found some operations and ideas cognitively easier to process in Vietnamese, as well as the example given to her by respected others, her mum and older sister. However, perceived difficulty with understanding or comprehension of the problem could be another important cue for her to switch. It seemed that, in Newman[3] terms, 'Nhung' was switching at the reading or comprehension stages of solving the problem because of perceived difficulty, but at the processing stage the relative ease in using Vietnamese, or the example of a respected other sometimes came into play. With her assumed frequent discourse about mathematics with both her mother and sister in Vietnamese, and her confessed knowledge to be able to count to high numbers and perform numerical operations when thinking in Vietnamese, one can guess that her mathematics register in Vietnamese was already elaborate and growing.

Two years after the initial interviews, a few of the students who had indicated they used Vietnamese to do some of their mathematical thinking in year 4 were again interviewed. 'Nhung' was one of these students. When 'Nhung' was completing the operations for the chocolate problem I asked:

Researcher: Did you do all of that in English or did you swap into Vietnamese to do any of that?
Student: Swap.
Researcher: Can you have a think back. . .
Student: Because Vietnamese and English are sort of the same
Researcher: Are they?
Student: Yes.
Researcher: Do you sometimes find yourself thinking in Vietnamese and sometimes in English?
Student: Yes.
Researcher: And you just seem to swap backwards and forwards?
Student: Yes.

This seems to be an example of the rapid switching between languages noted earlier in the literature, rather than a full switch into Vietnamese to think through the whole problem, as she seemed to be doing in year 4. However after 'Nhung' had struggled a little to comprehend the running problem which she did successfully in the end, she opined that all her thinking was in English, as was the processing of the mathematical operations. This was

so for all the other problems she completed at the interview. Hence by the time 'Nhung' was in year 6 the incidences of switching in mathematics had lessened, and when it did occur, it was of a different kind, so natural that she had some difficulty distinguishing the occasions.

'Vinny', like 'Nhung', had indicated that he had used Vietnamese reasonably frequently when completing the mathematical problems in class. However, in the interview situation, he indicated that he had not switched into Vietnamese at any time. He did, however, find some of these problems hard, and clearly reread a number of them to clarify the meaning for himself, and made some false starts before correcting himself. Interestingly, he said he did switch into Vietnamese when doing homework. He was not sure why he did this. 'Vinny' said he did not get any help doing his homework. So, presumably, help given in Vietnamese by a parent or older sibling did not prompt this switching. However, Vietnamese was the language spoken almost exclusively in the home. 'Vinny' also attended Vietnamese school and it seems to be there that he learnt to count to large numbers in Vietnamese. He also said he could complete the basic number operations in Vietnamese.

'Vinny' was still at the same school 2 years later and agreed to be interviewed again. In year 6, 'Vinny' said that he now never switched into Vietnamese when doing mathematics. However, later, when sifting together through one difficult problem in the interview, he did give an indication he had switched, but only "off and on". The only other times that he now switched into Vietnamese was when he was in a Vietnamese language situation such as in Vietnamese language classes in his school or at Saturday school, and at home talking to his parents. He used English more and more with his siblings. He still completed his mathematics homework by himself but now this was thought out in English. However, there was a time when 'Vinny' could remember using Vietnamese when doing mathematics:

Student: When I was in year 3 or 2
Researcher: Year 2 or 3?
Student: Yes.
Researcher: And why did you swap, was that just a habit, or did it happen at particular times?
Student: I think it happened with some of the hard ones, or the easy ones
Researcher: So it was a mixture of reasons?
Student: Yes.
Researcher: Okay, and when did you sort of stop doing that?
Student: I think when I was year, I think near the end of year 3.

This account more or less agrees with the other interview data. Maybe there are vestiges of an earlier strategy that 'Vinny' employed when the problem was hard, but it was a rare occurrence for him to use that strategy at the time of the year 6 interview. This interpretation does not account for 'Vinny' reporting that he used Vietnamese frequently when completing the classroom tests when he was in year 4.

4.5. *Discussion*

The ease with which the four students conducted themselves verbally in the introductory discussion to their interviews showed that they had a good grasp of both 'conversational' English and mathematical English. From comments made by the Vietnamese teachers either at the end of the interview, or on the report sheets they were asked to complete, the same could be said for these students for non-mathematical discourse when using Vietnamese. There were clear indicators in the analyses of the interview data that, in one way or another, all of the four students had a well-developed mathematical register in Vietnamese. They all had learnt to count to high numbers and could compute in Vietnamese, and one had the impression that they could do more. Just how far these students had moved in conducting more rounded mathematical discourse in Vietnamese was hard to decipher. It would appear there had been little opportunity for this, but with an aunt teaching one student, and parents involved in homework, there may well have been much more opportunity than can be adequately judged here. This is an issue that needs more investigation.

A number of factors were noted in the reviewed literature that are associated with students who switch between their languages in learning situations. In reviewing the interview data in the light of those factors, the first interesting point to note is something that at first may not be seen to relate to these students' language competencies. These students did make similar types of reading, comprehension and processing errors, such as one may find when completing a Newman investigation of errors made by year 4 students. However, the impression was gained that the error rate for these four students was less than would normally be expected, although this assertion needs further research. More importantly, when these students did make such errors, they could self-correct in most cases. These observations may well be linked to the students' heightened metacognitive ability. The self-corrections observed in the interviews may also link to these students' practice of checking and re-checking as a sub-strategy of sense-making for each step in their overall solution strategy. If this conjecture is correct, then it can be seen that these four students are exhibiting the types of beneficial

cognitive factors identified within the literature associated with students who switch languages.

For the four students in this study, perceived difficulty, the students' perceptions that they found some mathematical processes easier to complete in Vietnamese, and the influence of a respected other helping complete a similar problem, were all cues suggested by the students. These, either singly or in combination, influenced their switching between languages. However, in the present analysis, not all students clearly showed that they were indeed switching between languages when solving the interview problems. There are at least two possible explanations of why some students were not switching.

One student reported using Vietnamese at times when completing his mathematics homework, which he did by himself, and when he attempted the classroom tests. But during the interview he was adamant that he only used English. It could be that the context in which he was processing the mathematics may have influenced his behaviour. When in his private world, he at times slipped into the use of Vietnamese, but confronted by the prospect of having to explain his solutions in English, and indeed watched by a monolingual speaker while attempting the interview problems, he stayed in English. Hence, the context in which students find themselves may influence language use (see also Clarkson, 2002).

Another explanation of why some students did not switch languages relates to their maturation. For three of these students, there was an earlier period of time when they all remembered switching languages when doing mathematics, but at some point they gradually stopped this behaviour. It can be guessed that for 'Hien' this time seemed to be been just earlier than year 4, for 'Nhung' the transition happened in years 5/6 and for 'Vinny' the transition was coming to completion in year 6. If this notion is correct for students such as these, then there was nothing in the interview data of 'Son' to contradict this notion, but at the same time there was nothing to support it either. However, assuming this notion is correct, then he, too, had completed this transition process, probably well before year 4. One reason as to why this transition should take place at all, may be found in the study by Cuevas et al. (1995), reviewed above. These authors suggested that the Spanish speaking students they were studying, over some years finally took on the language of the teacher, English, even though the students were given support to develop their first language, including when doing mathematics. One might term this the influence of the teacher, in this case marking the appropriate language medium to use in class even if this was implicitly done. However the influence of the teacher might not be the full explanation. Other questions remain, such as whether it was simply these students' adeptness at switching languages that speeded up this transition

process, or whether deeper cognitive abilities acquired because of their switching between languages enabled the progress.. Both the impacts of context, and whether there is a transition to the use of the dominant language seem to be useful issues to explore in the future, perhaps starting with younger students in a longitudinal study.

In the summary of literature above, affect was another reason given as to why some students may switch. Some students simply said they like to, and others that it gave them more confidence. Both these responses relate to the feelings the student has after switching. It may be that the act of switching into their first language brings with it a set of familiar associations that the bilingual student enjoys. Since the student now feels he or she is on known conceptual territory, switching may give a boost in confidence in processing the problems. Whether this process was being observed or not, it was clear that the four students approached the solving of the interview problems with confidence, which was maintained even when they ran into difficulties. Interestingly, there did not seem to be any difference between those students who said they were switching and those who were not. However, if confidence is in part an outcome of switching, then the students who were not switching in the interviews may well have a sustaining level of confidence that was built up in the past, in part from their then practice of switching.

There did not seem to be any instances during the interviews of students just translating individual words to check their meanings. It seemed that, when at the reading and/or comprehension stage of processing a problem, either initially or at a subsequent point in the process, if the students did switch languages then they seemed to be translating the whole of the problem into Vietnamese. There did not seem to be any errors linking back to mistranslation that were obvious to the author or to the Vietnamese language teachers, when they were present in the interview. It has been noted already that students did from time to time undertake some of the arithmetic operations in Vietnamese. This strategy seemed to be independent of whether or not any reading or comprehending of the problem had been carried out in Vietnamese. There were instances of the three possibilities; both sub-processes occurring together, plus either process occurring independently. Clearly, however, this is an area that needs further investigation.

5. SUMMARY

This study has shown that in the urban Australian setting where bilingual Vietnamese students learn mathematics in their second language, normally with monolingual English speaking teachers, many such students from

time switch between their languages when doing mathematics. For these students, the competencies that the students have with both their languages are important in how well they perform mathematical tasks. This result is in line with earlier studies based on Cummins' theoretical framework.

The nature of the language-switching behaviours of the Vietnamese students, who had relatively high competencies in both their languages, appears to be largely unconscious and unplanned. Some of the bilingual teachers who observed the interviews first noted this. Further, it appears that the students had never been questioned before about their use of two languages during the problem-solving process, and often found the metacognitive tasks involved in discussing the issue difficult. Nevertheless, the methodology and analysis used was adequate for making sense of what happened. However, the complexity of the process in which the students were involved cannot be stressed enough. Any solution process in mathematics is complex, if it is more than rote application of a well-known routine for the student. With bilinguals there are clearly added fields of complexity. Hence the conjectures offered in this study are inevitably based on 'messy' data, not because there was an inadequate methodological approach, but the very nature of the phenomena is complex and 'messy'. However such projects will continue to give rich insights into how students learn mathematics.

For these highly competent Australian Vietnamese language students, in line with the literature reviewed, switches between their languages were related to the help important others had given in the past, and/or by the setting in which they were doing the mathematics. At other times, the switching was of a cognitive nature, particularly because the problem was proving difficult to solve, and less often because the student thought it was easier to solve in Vietnamese. It was clear that the switching was often for the whole of the processing of a problem, or for the whole of a sub-process within the total solution strategy. There were no occasions observed when only single words or phrases were translated from one language to the other. However, it was also true that these students were moving to using only the dominant language of teaching in the classroom (English) or had already reached this stage, although there seemed to be a time for all of them switching when doing mathematics was frequent. The data implied that their metalinguistic/metacognitive abilities were of a higher order than would be expected of year 4 students, as predicted in the literature. These last two points, plus the students' ready confidence in doing mathematics, are the three matters that should be followed up in more depth since each of them has important implications for teaching.

It became evident in discussion with teachers that language switching was relatively unknown by them. Many said they had simply not suspected

it was going on during mathematics classes; this was so even for some teachers who had undertaken graduate studies in teaching English as a second language. However, the knowledge that students often do use both their languages when doing mathematics in the hands of a sensitive teacher, can be a powerful means of understanding students' thinking. Teachers who acknowledge this use, affirm it, and encourage it, while steadily building the students' competence in English, will be enhancing their students' long-term mathematical performance. This project goes some way to furthering this change.

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NOTES

1. This reference is to an unpublished paper: 'Cuevas, G., Silver, E.A. and Lane, S.: 1995, QUASAR students' use of Spanish/English in responding to mathematical tasks, Paper given at the annual meeting of the American Educational Research Association, San Francisco', and available from Prof. Cuevas at gcuevas@umiami.ir.miami.edu.
2. Newman developed an interview strategy based on five stages through which students normally move when solving one-step mathematical word problems. The first two stages she called 'reading' and 'comprehension'. Her results drew attention to the little recognition that was given at that stage to reading and comprehension errors made by students in their solution processes (Newman, 1983).
3. See note 2.

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