2008, Vol. 20, No. 1, 52–81 *Mathematics Education Research Journal*

Iranian Bilingual Students Reported Use of Language Switching when Doing Mathematics

Zahra Parvanehnezhad
University of Melbourne

Philip Clarkson
Australian Catholic University

Teachers are often unaware that bilingual students often switch between their languages when doing mathematics. Little research has been undertaken into this phenomenon. Results are reported here from a study of language switching by sixteen Year 4/5 Iranian bilingual students as they solved mathematical problems in an interview situation. Reasons given for switching between English and their L1 language (Persian or Farsi) were the difficulty of the problem, familiarity with particular numbers or words they used habitually in Persian, and being in the Persian school or interview environment. It seems likely that these Iranian bilingual students will continue to use some form of language switching to help them understand and complete mathematical tasks in mainstream classrooms.

It has been estimated that approximately 60% of the world's population is either bilingual or multilingual; that is, more than half the people in the world routinely use two or more languages in their daily communication (Baker, 2001; Padilla, 1990). Multilingualism and multiculturalism are social facts of this new century, which can be seen in most classrooms and playgrounds (Luke, Comber, & O'Brien, 1996). For bilingual students in an English as a second language learning context, being able to speak, read and write in the English language is critically important as "English is the main language required for school success and interaction with the wider society" (Molyneux, 2004, p. 6). However, the role played by bilingual students' first language in such a learning environment is also important.

Australia is a country with considerable ethnic and cultural diversity. Forty per cent of the total population are either first or second generation Australians (Swetnam, 2003), and these include immigrants from Iran. After the 1979 revolution in Iran, the number of Iranians migrating to Australia rose. But in the 1980s, during the period of war between Iraq and Iran, the number increased to record proportions. Newcomers from Iran settled in different parts of Australia with most settling in Sydney, Perth, and Melbourne. Today, there are approximately 5,000 Iranian migrants living in Melbourne (Homayooni, 2004). Most Iranians living in Australia have Persian (Farsi) as a first language (L1) and English as a second language (L2).

The first author was one of these Iranian immigrants who speaks Persian as her L1 and English as her L2. As an educator, as well as an individual, she was interested in how she and other bilinguals used their languages in communicating and thinking. In particular, she was impressed by the interplay of languages used by her children. In contrast, the second author is a monolingual English speaker, but like the first author has been interested in how bilinguals used their languages in communicating and thinking. In particular, both authors are teachers of mathematics, and are interested in what role language switching may have when bilingual students deal with mathematical ideas. In this article we report on Iranian students living in Melbourne, Australia.

Early in the study reported here, a visit to two Persian language schools in Melbourne provided an opportunity for the first author to further discuss language switching with the Persian language teachers. One of the teachers volunteered that most of her students switched between Persian and English when mathematical ideas arose. For example, she noted that they would switch languages for particular number words, while studying Persian in the classroom. But she was not sure how often that occurred and whether there were particular prompts for this behaviour. This study has focussed on addressing these questions.

In reviewing the mathematics education literature for different bilingual groups, it became evident that, although there were some studies on language switching in some ethnic groups, there was no study in this regard with Iranian bilingual students in Australia, or elsewhere. This research therefore, was designed to start to explore the extent to which language switching was used by a group of Iranian bilingual students when solving mathematical problems. But before dealing with this particular issue, a brief review of the wider issue of bilingualism, and then bilingual students learning mathematics, will be given.

Bilingualism

Up until the 1960s, it was commonly assumed that bilingual students who were learning in their second language must inevitably have been at a disadvantage. This notion began to be challenged in the 1970s and 1980s. A closer examination of the results of bilingual students across various subject areas, including mathematics, showed inconsistent results. Although it seemed to be true at times that bilingual students as a whole did not perform as well as their monolingual peers, there were also some results that showed bilinguals excelled.

Following Lambert's (1977) claim that a high level of language proficiency in bilingual students contributed to their educational performance, important theoretical work was undertaken by Cummins (1979, 1991, 2000). Central to this area of Cummins' work is his so-called "threshold" hypothesis which accounts for the impact of the bilinguals' language proficiencies on their academic performance. There are a number of notions that need to be considered: whether the students are balanced bilinguals, the level of proficiency that the bilinguals have in each of their languages, and the environment in which they learn. Balanced bilinguals are bilinguals who have equal proficiency in their languages. There are also bilingual students who are not balanced bilinguals, but have a clear dominance in one of their languages. The second aspect of Cummins' work to highlight here is it is not just the proficiency that students have in the language of teaching — normally the students' L2 — but that the proficiency they have in their L1 is crucial for their learning. The third notion that has an impact is a social issue. It can be assumed that the language of teaching (the students' L2) has high social standing in the wider society, but this is not necessarily so for the students' L1. For students to gain an advantage from their L1, this language must be perceived as carrying the academic discourse of the students' schooling. When this does occur then students are said to be in a language additive environment where both their languages can contribute to their cognitive development. If the students' L1 is not regarded as being able to carry the academic discourse (and in these circumstances the students' L1 is often being replaced by their L2) then they are said to be in a language negative environment. This may contribute to non-enhancement of learning.

To draw these notions together, in effect students are tested in both their languages and those who are deemed to have high proficiency in both are said to be above an upper threshold, whilst those who are deemed to be weak in both their languages are said to be below a lower threshold. Students who are 'one dominant' are placed between these two thresholds (see Table 1). Across a number of subject areas it is found that students above the upper threshold have a cognitive advantage, while those below the lower threshold are disadvantaged (Cummins, 2000). These results hold even after the impact of SES, cognitive development, IQ, family background and other potentially important variables are removed from the analyses.

Table 1
Types of bilingualism and outcomes

Type of bilingualism	Threshold	Cognitive impact
Balanced bilinguals with high competencies in L1 & L2	Upper	Positive
One language dominant	Middle	Neither positive nor negative
Balanced bilinguals with low competencies in L1 & L2	Lower	Negative

Note. From *Bilingualism and mathematics learning* by P. C. Clarkson, p. 14. Copyright 1991 by Deakin University Press. Adapted with permission of the author.

Mathematical Learning and Bilingualism

Solving mathematical problems is generally described as an organised multi-step task involving understanding the question, choosing a plan, implementing appropriate solution strategies, and reflecting on a performed task (National Council of Supervisors of Mathematics, 1989; O'Connell, 2000; Schoenfeld, 1992). Lerman (2001), with slightly different emphases, described the elements of solving mathematical problems in terms of negotiating "mathematical meanings", "the use of mathematical language", and "the use of strategies". All of these are "the tools with which students think and speak mathematically" (p. 107). Like others before him (e.g., Ellerton & Clarkson, 1996; Pimm, 1987), Lerman explicitly highlights the importance of language on mathematical learning and focuses particularly on the problem solving process. However, for bilingual students, the learning of mathematics and solving mathematical problems, the situation is more complex. Not only with the traditional reliance on reading written resource material, but also with the increased focus on discussion and/or classroom interaction that has arisen as a result of reform initiatives based on a socio-constructivist perspective of learning (Barwell, 2005), the linguistic demands have increased in mathematical classrooms in general, but, in particular, for bilingual learners.

Over the last 25 years, an interest in the way bilingual students learn mathematics and solve mathematical problems has drawn on a variety of theoretical frameworks (e.g. Adler, 2001; Moschovitch, 1996). Of particular interest for this study, the work of Cummins, briefly described earlier, has also been shown to apply to the learning of mathematics. It has been found that bilingual students with high level proficiency in both their languages outperform their peers in mathematics for whom one language was dominant, or who had low competency in both their languages. This language impact is evident even after potential influencing variables are accounted for (Bernardo, 1999, 2002; Bernardo & Calleja, 2005; Clarkson, 1991a; 1992; 1996; Clarkson & Dawe, 1994, 1996; Clarkson & Galbraith, 1992; Dawe, 1983; Erktin & Akyel, 2005; Latu, 2005).

Clarkson and Dawe (1994) suggested a need to explore how bilingual students used their languages when doing mathematics, since it was likely that it was in these processes that the cognitive benefit accrued. They suggested that one avenue worthy of further research was the phenomenon of students switching between their languages when solving a mathematical problem. Following Cummins, they speculated that in switching between their languages, students might well be developing the nuances of mathematical notions, and hence gaining a deeper understanding of mathematical ideas and processes. Possibly for some of these students, this process was inadvertent and not a deliberate strategy, yet benefits would still accrue. Clearly, it is in the teacher's interest to be aware of any such strategies that students are employing to solve mathematical problems, either individually or in small group discussion. If, however, the teacher is unaware of students' strategies, then any advice or indeed overt teaching they engage in may well create confusion for the students.

Any student, irrespective of language background, may sometimes experience difficulty with comprehending the written text of a mathematics question. This may be attributed to difficulty in reading the problem, or it may be attributed to lack of understanding of the concepts within the problem (Laborde, Conroy, De Corte, Lee, & Pimm, 1990). Bilingual students' difficulties with reading and conceptual understanding may prompt language switching, as students attempt to resolve this impasse (Clarkson, 1991b; Clarkson & Dawe 1996; Latu, 2005). Similarly, if students are unsure of the meaning of critical mathematical symbols used in a problem, then this may also prompt language switching. In his research Latu (2005) found Pasifika students were switching between languages in an effort to understand the ‘<’ and ‘>’ symbols.

When students progress pass the stage of reading and understanding the problem, they may well have difficulties in deciding the appropriate mathematical plan of action and/or in selecting the correct mathematics to apply to the problem. Again difficulties with this aspect of the solution strategy prompt bilingual students to switch languages (Bernardo, 1999; 2002; Bernardo & Calleja, 2005; Linthorne & Doolan, 2003; O'Connell, 2000). Hence, when asked to solve what for them is a difficult mathematical problem, bilingual students may at any stage in the solving process try and use their L1 as part of their solution strategy. However there are a number of other factors that have also been shown to initiate students' switching between languages.

In the most recent relevant study, Clarkson (2006) noted that for a group of high performing Vietnamese bilingual students completing their schooling in Australia, some mathematical processes were easier to complete in Vietnamese. Clarkson showed the influence of a respected 'other' helping in processing the problem. Some students in the study simply like using Vietnamese; and others suggested that using Vietnamese gave them more confidence. It seemed that no Vietnamese student simply translated one word into their L1 to check its meaning. If they did switch languages, for whatever reason, then they did so for a significant chunk of the problem, or indeed the whole problem. Thus, although teachers should be aware that difficulty experienced in solving a mathematical item may be one reason (and a frequent one at that) why students use a switching language strategy during the solving process, this is by no means not the only possibility since students may well switch between their languages for a variety of reasons.

This brief review of the literature is guided by a constructivist view of teaching and learning, that holds that the teacher is not the source of all knowledge. One aspect of the teacher's role is to elicit from students' their understandings at any given time. When teaching bilingual students, this means that some of the students' understanding will have its foundation in a L1 language context, not a L2 language context, even if the L2 is the language of the classroom. Hence, at a very basic level, when teachers are encouraging bilingual students to explore their own approaches to solving mathematical problems, they will, by implication, give students permission to use their L1 in that process. However, if teachers are unaware of bilingual students' use of a language switching strategy, they will also be unaware of the full ramifications of the permission they have given.

One interesting example from South Africa is informative. Setati (1998) was working with Year 4 students in South African classrooms where the teaching language was English. Teachers and students both switched to their language (Setswana) at times in the mathematics lesson. Setati reported that this was because the learners communicated their mathematical thinking more easily in Setswana, although they also realised they had to become competent in mathematical English. The switching improved the mathematical interactions in the classroom. Vithal, Adler and Keitel (2005) reporting the results of a series of studies conducted with primary students also in South Africa by Ncedo, Peires and Morar (2002) and by Adendorff (1993) noted that language switching is used "to enable both learner-learner and learner-teacher interactions" more easily to occur (p. 93). Adler (2001) summarised the South African context as follows:

> As research and development in language and learning in bi/multilingual settings has shifted from regarding the learner as in some way deficient to embracing the presence and use of more than one language in teaching and learning as resource, so code-switching has become a taken-for-granted 'good thing'. (p. 75)

The Importance of Specific Language Contexts

Clarkson and Dawe (1994) suggested, given that so little was known about bilingual students' use of their languages when solving mathematical problems, it may be prudent to treat each group of bilingual students separately. Reflecting on this theme, Clarkson (2004) and Barwell (2005) both suggested that although there are clearly major themes that apply across all multilingual teaching/learning contexts, there will always be crucial specific language/cultural issues that must be taken into consideration in any specific contexts. Although different language groups have been represented in the review above, the L2 in each case was English. Dawe (1983) was working with students from Italian, Punjabi, or Mirpuri backgrounds. Clarkson reported on work with Papua New Guinean students (Clarkson, 1991a; Clarkson & Galbraith, 1992). He and Dawe later worked with students with Vietnamese, Italian and Arabic backgrounds (Clarkson, 2006; Clarkson & Dawe, 1994, 1996). Other researchers worked with Filipino students (Bernardo, 1999, 2002; Bernardo & Calleja, 2005), South African students (Adler, 2001; Setati, 1998), and students with Samoan and Tongan Pasifica backgrounds (Latu, 2005). In summarising this literature it seems clear that there are commonalities across the L1s investigated as to why students switch between their languages; but this is no guarantee that these reasons will apply for quite a different type of L1.

To the best of the authors' knowledge, there is no literature regarding language switching by Persian/English bilingual students in Australia, or indeed elsewhere. Arefi (1997) conducted the only other study we could find with Iranian students in Australia. She worked with 70 Iranian Year 3, 4, and 5 students. Similar to the students of the current study, these students attended NSW State primary schools during week days and Persian schools on weekends. However, her study investigated the role of L1 literacy in L2 acquisition. Arefi found that English language writing development "relies strongly" on Persian language proficiency (p. 232). She reported that:

> Writing skills in English (L2), in a bilingual milieu (Australia), among Iranian primary school children who were instructed in their first language and at the same time attended regular Australian schools, appear to be related to Farsi (L1) writing skills. (p. 231)

Based on the considerable differences between the structures of Persian and English, it was of interest to explore the extent to which Iranian bilingual students would switch between their languages, and why they did so, when solving mathematical problems in the Australian context. Therefore it was decided to explore the following research questions:

1. Do Iranian non English background (NESB) students, based in Australia, report that they switch languages when solving mathematical problems?
2. What factors prompted language switching (if any) with this sample of Iranian bilingual students?

Methodology

To address the research questions of this study, a qualitative research approach was used to explore how a specific group acts in a particular situation (Patton, 2002). More specifically, a qualitative case study methodology was selected as it allows investigators to focus on a specific group or system as "an entity in itself" (Burns, 2000, p. 460). In general a case may be an individual, a school, an organisation or a particular group, but the specific case should be bounded and be clearly defined (Stake, 2000). The main focus of a case study is to gain a wealth of detailed information on a small sample size that is selected specifically so the research questions can be addressed (Patton, 2002).

In the study reported here, the aim was to examine whether language switching occurs, and if so, to establish a deeper level of understanding of why a group of Iranian students from a non English speaking background used language switching when they were solving different types of mathematical items. Previous research studies with bilingual students (Adler, 2001; Bernardo, 2002; Bernardo & Calleja, 2005; Clarkson, 1992, 1996; Clarkson & Dawe, 1996) have used one-on-one interviews, or surveys of students, or both. In most of these studies students were asked to complete a mathematical test immediately before completing the survey or interview, or were asked to attempt a mathematical item during the interview. These approaches seemed very appropriate for this study.

Sample

In this study, the case was limited to sixteen students in Year 4 or 5 who were studying in Victorian primary schools on weekdays and attending one of two Persian language schools on Saturdays. These are the only Persian language schools in Victoria that teach the Persian (Farsi) language to Iranian NESB students. The classes focus solely on language teaching and any instruction in mathematics is incidental.

Nine students attended the first language school and seven students the other. There were eleven Year 4 students (8 boys and 3 girls), and five Year 5 students (1 boy and 4 girls). Most of the students participating in this study began their schooling in Australia. The students spoke Persian as their first language and often spoke it at home. All parents were Iranian and spoke Persian as their first language. Therefore the students were regarded as being bilingual with Persian (Farsi) as their first language (L1), and English as their second language (L2).

Instruments and Procedures

The first author conducted all the data collection. Fluent in both Persian (her L1) and English, she was an experienced mathematics teacher.

Mathematics questions. To explore the incidence of language switching used by these Iranian NESB students when solving mathematical problems, ten mathematics questions were individually administered to each student. The mathematics questions were administered directly after their Persian classes while they were in Persian schools. Questions were selected from a pool of thirty items appropriate to the students' year levels. Each item was given a difficulty rating of high, average or low. The level of item difficulty was assigned by a group of expert researchers and teachers before the students were involved in the study. This experienced group used a combination of criteria, such as the complexity of the wording of an item, the size of numbers, the number of steps that it was anticipated students would use to solve an item, the number of addends, and so forth, within an item, and their own experiences of what types of items students at different grade levels have found easy or difficult. On average, students attempted five symbolic items, four word problems, and one open-ended question. Symbolic items were presented as equations or in the form of vertical algorithms. Questions on addition, subtraction, multiplication, and division were included, together with a multi-step problem that involved a combination of operations. The word problems were virtually all number problems embedded in measurement, time and spatial contexts. The open-ended questions were drawn from a variety of contexts and all had more than one correct answer. An example of each type of problem at an average level of difficulty is presented in Table 2.

Table 2
Types of Problems of Average Difficulty

Type of problem	Example
Symbolic question	38 x 6
Word	Anna's birthday party will start at 12:45 pm. It is 10:50 am now. How much longer does she have to wait?
Open-ended	Chocolate bars cost $2.50 each. Muesli bars cost $1.50 each. Ali had $50. He bought 4 chocolate bars and some muesli bars. How much money did he have left?

Since it was anticipated that the students' abilities to make a start on the mathematical questions would vary, an average level question was used initially. If a student was unable to make a start, an easier question was given. If it appeared that the question was too easy, a more difficult one was selected for the next question. While the students solved the mathematics problems and recorded their solution on an answer sheet, the first author carefully observed and noted their reactions while the student attempted each question. After the interview was completed, the items were scored using a three category rubric (see Figure 1).

Survey. A survey instrument called the 'Language Switching Checklist' (LS Checklist) was attached to each student's answer sheet. This provided a way for students to record the language(s) they used when solving the mathematical items. The LS Checklist became the basis for a one-on-one interview, which incorporated, when appropriate, a 'think aloud protocol' (see next sub section). Using a checklist on which students had to respond in the first instance in writing, and then later exploring their written responses verbally, was on balance preferred over an initial verbal response think aloud protocol. It was thought that to use a verbal think aloud protocol at the beginning of the student interactions in this project may have interfered too much with the students' thought processes. We were concerned for two reasons. First, with a researcher who students were likely to regard as a 'teacher' sitting next to them and listening to

Scoring Code	Description
Incorrect (IC)	Incorrect, does not recognise operation(s) required, no response, working or explanation. E.g., $\begin{array}{r} 780\ + \\ 8 \\ \hline 1668 \end{array}$
Partially correct (PC)	Incorrect, recognises the operation(s) required, makes a start, but generally unable to complete procedure or perform strategy, some working and/or explanation may be provided. E.g., $\begin{array}{r} 9 \\ \hline 8\ )\ 780 \\ 6 \end{array}$
Correct (C)	Correct, uses appropriate procedure/strategy and interprets result relative to context. E.g., $\begin{array}{r} 97.\ 5 \\ \hline 8\ )\ 780 \\ 60 \end{array}$ Answer: \$97. 50

Figure 1. Scoring rubric for mathematics items.

them talk, the students may have assumed they needed to use the English language for their thinking, since this was the way they normally responded to teachers. Alternatively, some students may have thought they needed to use Persian, since they had been told the researcher spoke Persian. Hence it was decided that if the students responded in writing on the LS Checklist in the first instance, and not verbally, then their thinking may be less influenced by the researcher's presence. It is also noted that a survey approach has also been used to good effect in past research studies (e.g., Clarkson, 1996; Clarkson & Indris, 2006).

The LS Checklist (Figure 2) had two columns for each question, one headed English (L2) which was ticked if English only was used in solving the item, and one headed Persian and English (L1 & L2) which was ticked to indicate that L1 had been used at some time in solving the question. The LS Checklist was completed in a step-wise fashion. Each student, immediately after "solving" a problem, filled in the LS Checklist for that question.

The immediacy of students completing this checklist item-by-item seemed to help students remember events of language switching (if any). By contrast, in an earlier study Clarkson (1996) had videotaped individual students discussing their solution strategies, but only after they had completed a set of 4 to 5 problems. The strategy used in this study minimised the time delay between students solving the problem and recording what they did. In minimising this time delay, recognition is given to a fundamental issue inherent in collecting such self-response data. Specifically, a researcher (and at times the respondent) can never be wholly sure that the responses given actually reflect what was happening with the respondents' thinking as they processed a particular problem. Even so, there have been claims that students' recall is very good for up to 48 hours after an event (Marland, 1987). In this study there was no indication that the students were not cooperating fully with the interviewer, and trying to

Question	English Language only (L2)	Persian and English Language (L1 and L2)
1		√
2		√
–		
–		
10	√	

Figure 2. Partially completed language switching checklist for students.

complete the survey as requested. Secondly, in minimising the time delay to a matter of seconds, presumably it was easier for students to remember more accurately what they had just done. Thirdly, with such a short delay, there was less time for extraneous events to interfere with memory.

Interview questions. Immediately following the completion of the ten mathematics questions, the first author engaged each student in a discussion based on their answer sheet and the completed LS Checklist about the processes they used in solving the mathematical items. Part of this discussion was centred on trying to ascertain the reasons that prompted any use of the Persian language (language switching). The discussion was begun in English and this was the language predominantly used. However, if a student moved to Persian, the first author (who is bilingual) matched the student's language if this was judged to be appropriate, so as not to influence the student's language choice.

The questions invited students to refer to their completed LS Checklist and/or their working and included the following:

1. How did you answer the question? What did you do first? And so on. (Often these types of questions prompted the student to again work through the item, explaining at each step what they were doing. In effect, this became a think aloud protocol.)

At appropriate points in the discussion, questions such as the following were asked:

2. What language did you use to begin to solve the problem?
3. Did you switch between languages? At which stage?
4. If you used the Persian language for doing the mathematics questions, why?
5. If you used the English language for doing the mathematics questions, why?
6. Is there any word/statement that would be difficult to translate directly into Persian (Farsi)?

All student interviews were tape-recorded. During the interview, the interviewer made field notes as to any significant points such as the reactions and the general approach of the student, and so on.

Languages and mathematics Competencies. The main focus of this study was to determine whether students switched languages while doing mathematics. The issues of mathematics and language competencies, and any relationship between them, were not the crucial issue for this study. However it was useful to have some measures that gave an indication of the students' competencies in mathematics, English and Persian. For example, some indication of the students' language competencies was a checking device to ensure that the study was really dealing with bilingual students. Second, a simple comparison of the mathematics and language competencies may give some indication whether the relationship found in other studies existed in these data. However, with a small number of students in this study, it is not appropriate to interrogate the data extensively. Finally, some measure of competencies may help in the interpretation of other results of this study.

The mathematics items that students completed have been described above. On the basis of their solutions and how they attempted these mathematical items, students were assigned to one of three groups as follows:

- *High Mathematical Competency*: Able to solve most mathematics questions correctly at a level of difficulty appropriate to their age level,
- *Average Mathematical Competency*: Generally makes a start on average or hard questions but unable to answer correctly, but able to solve easy questions most of the time, and
- *Low Mathematical Competency*: Experiences difficulty making a start or solving any questions.

For example, one student who was categorised at an average level of competency in mathematics was able to recognise the correct algorithm when solving an average word problem involving division, but he was unable to solve this problem completely. However, he was able to solve the easy symbolic question involving addition or subtraction algorithms correctly and quickly.

The students completed two language tests, one in Persian and one in English, to give an indication as to their competency in these languages. Although language competencies were of some interest in this study, as explained elsewhere it was not the crucial issue. Hence it was sufficient in this study to classify students according to high or low competency in each of their two languages. For the English language measure, an English language test often administered in Victorian primary schools was used (Mossenson, Stephanou, Forster, Masters, Anderson, & Hill, 2003). The maximum score for this test was 9, and students who scored above 6 were deemed to have high competency in English. In the absence of any available measure of Persian language competency, the first author, helped by the Persian language teachers, developed a series of short comprehension items with variable difficulty. Ten were selected for the test. This was conducted on a one-to-one basis with all instructions in Persian. The maximum score for this test was 10, and students who scored above 7 were deemed to have high competency in Persian.

Once the students had completed the language tests, and the first author scored the tests, the results were shown to the relevant teachers in the Persian language schools. None of the scores obtained by the students surprised the teachers; nor did the language scores surprise the first author, after she had worked with the students. The teachers' and author's reactions were taken as a general endorsement that the scores were a reasonable measure of the students' language competencies.

Data Analysis

The students were classified as having high, average or low competency in both their languages and for mathematics as described above. These results were analysed by a simple tabulation exercise.

All of the student interviews were transcribed. The transcripts were then carefully read and re-read a number of times, and annotations added to identify any evidence of language switching as it occurred, as well as possible prompts for language switching. A matching between the transcript annotations and the data from the 'LS Checklist' was then undertaken.

Once the initial data analyses were completed a second phase of analyses proceeded. The first step was based on the mathematical questions. This analysis involved organising all the information about students' use of language switching for each question, including students' reasons for using the Persian language (L1). Once the data had been organised in this manner, it was inspected to find patterns of language switching in relation to mathematics performance, type of question, and item difficulty. To illustrate these steps, the data for two students, AN4 and LA5, are shown in Table 3. This shows the students' mathematics performance, the frequency of language switching for each type of question, where language switching occurred, and their language and mathematical competencies. AN4's performance on the mathematics items attempted was classified as indicating a low level of mathematical competence. He used language switching in three questions (one word problem and two symbolic questions), switching to Persian (L1) to read the digits 3 and 9 when solving a symbolic question involving subtraction. Student LA5, however, switched to L1 in two questions (one word problem and one symbolic question). Although her performance indicated a high level of mathematical competence, she also used L1 to write and read the numbers 3 and 9. Possible patterns in language switching and the reasons for language switching were identified for all 16 students by examining similarities and differences in this manner.

Results

After briefly considering the relationship between language and mathematics competencies, results that focus on the central issues of this study, whether this group of Iranian students reported switching between their languages when attempting to solve mathematical questions, and if so what may have contributed to this behaviour, will be considered. Firstly, the impact of item type and of item difficulty, and secondly the explanations offered by the students when they were interviewed, will be investigated.

Language and Mathematics Competencies Relationship

An examination of the students' results from the results on the Language Tests they completed showed that all students had some competency in both English and Persian. These results, together with the opinions of the Persian language school teachers and that of the first author who had conversations with all students, showed that there was little doubt that all students were bilingual and did use both their languages at various times in their everyday lives. The students were then assigned to one of three language competency categories. The results revealed that five students had high competencies in both their languages, three students were 'one dominant', and the other eight students had low competencies in both their languages.

Table 3
Second Step of the Comparative Analysis for Two Students

	Student	
Criterion	AN4	LA5
Mathematics performance	*Open ended questions:* {1} (drawing): PC *Word problems:* {5} Division (3 digits ÷ 1 digit): PC Time (Anna task): PC Multiplication (2 digits x 1 digit): PC Addition (2 digits + 2 digits): C 3 steps (2 Multiplication and 1 Addition): C *Symbolic*: {4} Multiplication (2 digits x 1 digit): PC Subtraction (3 digits - 2 digits): PC Division (2 digits ÷ 1 digit): C 2 steps (Multiplication and Addition): C	*Open ended questions:* {1} C *Word problems:* {6} Division (3 digits ÷ 1 digit): PC Time (Anna task): C Multiplication (1 digit x 2 digits): C Subtraction (3 digits - 3 digits): C Addition (2 digits + 2 digits): C 2 steps (Addition and Division): C *Symbolic*: {3} Multiplication (2 digits x 1 digit): C Subtraction (3 digits - 2 digits): C 2 steps (Division and Subtraction): C
Attempted questions	10 (4 symbolic, 5 word, 1 open ended)	10 (3 symbolic, 6 word, 1 open ended)
LS (type of questions)	In 3 questions (2 symbolic, 1 word problem)	In 2 questions (1 symbolic, 1 word problem)
Where or when LS occurred	Average word (Division): LS in number (780). He was unable to say 780 in Persian properly so came back to English. Average symbolic (123 - 39): LS in 3 and 9 and *bebar* (take) Easy symbolic (48 ÷ 3): LS in 3 and 48	Hard word Soccer task (Subtraction): LS in 50 - 46 and 10 - 3 and *chand mishe* [how many in Persian], (when solving). Average symbolic (123 - 39): LS in subtraction sign and 123 when reading (also writing was in Persian).
Mathematics competency	Low	High
English competency	Low	High
Persian competency	Low	Low

Note. PC = Partially Correct. C = Correct. The number in { } indicates the number of items of the particular type attempted.

As noted earlier students were also classified as to their mathematical competencies. This resulted in seven students rated as having high mathematical competency, four with average competency, and five with low mathematical competency.

It was noted above that past studies have shown that there is a relationship between language competencies and mathematical competency. Table 4 shows this relationship for the Iranian group of students, whose results were consistent with previous studies. Most students with high/high language competency also had high mathematics competency, and most students with low/low language competencies had low mathematics competency. Most 'one dominant language' students in past studies have also had high or average mathematics competency. In this study they have fallen in the high mathematics category. With so few students, and no available covariable data to feed into the modelling, it is not appropriate to subject these data for further statistical testing. However this simple comparison does suggest that the relationships between these Iranian students' language and mathematical competencies may follow the patterns found in past studies. However, no more should be conjectured on this issue for this set of data.

Language Switching, Item Type and Item Difficulty

Of the sixteen students, fourteen switched to Persian for solving at least one question (counted as one incidence of language switching), while two students did not switch languages for any of the items attempted. Of the fourteen students who switched to Persian, all switched to their L1 when solving word problems, ten when solving symbolic items, and four switched to L1 for open ended questions.

Table 4
A Comparison of Students' Language and Mathematical Competencies

	Mathematics Competency		
Level of language competency in first and second language	High	Average	Low
High/High[a]	3	2	0
One Dominant	3	0	0
Low/Low	1	2	5

Note. High/high means high levels of competency in Persian and English, similarly, for low/low.

While this finding is of interest, the incidence of language switching in relation to item type is more likely to shed light on what might lie behind the use of language switching to solve mathematical questions. This can be viewed in terms of the proportion of students who used language switching for different item types. However, where students are asked to solve a disproportionate number of items of different type this approach can mask the actual rate of language switching. In this case, it is better to view the incidence of language switching in relation to item type in terms of the number of language switching events as a proportion of the number of different types of question attempted. For example, based on data from the interview transcripts, all fourteen students switched to the Persian language when solving word problems, while ten students switched to L1 when solving symbolic questions, and four students switched to L1 to solve open-ended questions. This finding suggests a possible relationship between word problems and language switching. However, as indicated above, this result needs to be interrogated further as there is a likelihood that it might have been unduly inflated by the number of questions of this type that were considered. For instance, the lowest incidence of language switching occurred for open-ended questions but only one question of this type was attempted by each student.

One way of examining this more closely is to consider the incidence of language switching not only by item type but by level of difficulty. The frequency of students who switched to the Persian language across different levels of item difficulty (easy, average, hard) and item type (open-ended question, word problem, symbolic item) is presented in Table 5. It can be seen in Table 5 that for word problems, with an increase in item difficulty, there is an increase in the number of students who switched to their L1, suggesting a possible relationship between language switching and item difficulty for this type of questions. However, in open-ended and symbolic questions there is no specific trend (pattern) between item difficulty and incidence of language switching.

Table 5
Frequency of Switching to L1 by Level of Difficulty and Question Types (N = 14 students)

	Number of students switching to L1		
Question type	Easy item	Average item	Hard item
Open-ended	0	3	1
Word problem	2	6	10
Symbolic	7	7	3

As indicated above, although frequency analysis sheds some light on what might be prompting the use of language switching, there was a possibility that it could distort the actual picture. By focussing on the number of questions attempted rather than the number of students, the proportion of language switching was examined across the three types of questions (symbolic, word problem, or open-ended question). The results are presented in Table 6. This table confirms that most language switching occurred in word problems for this particular group of Iranian bilingual students. However, the relative proportions are not as disparate as they first appeared, revealing that symbolic questions prompted almost as many language switching events as word problems.

Table 6
Frequency of Language Switching by Question Type (N = 163 items)

Question type	Frequency (%) of language switching events
Open-ended[a]	4 (25%)
Word problem[b]	27 (30%)
Symbolic[c]	16 (28%)

Note. [a]n = 16. [b]n = 89. [c]n = 58.

To investigate the relationship (if any) between language switching and the level of item difficulty (easy, average, and hard), the number of language switching events was considered as a proportion of the number of questions attempted at different levels of difficulty. These data are shown in Table 7. As can be seen, irrespective of item type, the proportion of language switching events appears not to be affected by item difficulty alone. Although it is possible that average and harder items may be more likely to prompt language switching than easier items, too few easy items were considered to test this claim in this instance.

Table 7
Frequency of Language Switching by Item Difficulty (N = 163 items)

Item difficulty	Frequency (%) of language switching events
Easy[a]	8 (26%)
Average[b]	19 (32%)
Hard[c]	21 (29%)

Note. LS = language switching. [a]n = 31. [b]n = 60. [c]n = 72.

Although it would appear that language switching mostly occurred in word problems and symbolic questions (Table 6) and may occur more frequently in average or hard items (Table 7), it is not clear from these two tables that either item type or item difficulty has a direct relation to language switching. In order to provide a clearer picture of language switching, it is useful to consider the proportion of language switching by item difficulty and item type in relation to the number of questions attempted. These data are shown in Table 8.

Table 8
Occurrence of Language Switching by Question Type and Difficulty of Items (N = 163 items)

Question Type	Attempted	Frequency (%) of LS
Easy Open-ended	0	0 (0%)
Average Open-ended	4	1 (25%)
Hard Open-ended	12	3 (25%)
Easy Word problem	12	2 (17%)
Average Word problem	35	11 (31%)
Hard Word problem	42	15 (36%)
Easy Symbolic	19	6 (32%)
Average Symbolic	21	7 (33%)
Hard Symbolic	18	3 (17%)

Note. LS = language switching.

In contrast to Table 5, which simply reported the incidence of language switching by students across the different question categories, Table 8 shows the proportion of language switching in relation to the total number of questions of each type considered. From these data it can be seen that while the proportion of language switching increased with item difficulty for word problems, the proportion of language switching did not increase with item difficulty for either symbolic or open-ended questions. It also shows that language switching occurred more frequently in hard word problems and average symbolic questions. The least language-switching incidence was in easy word problems and hard symbolic questions.

The proportion of language switching events associated with hard word problems may be due to difficulties comprehending language used in the word problem and/or the context of these items. This reasoning would also seem to apply to the open-ended items. However this reasoning does not explain the relatively high incidence of language switching in easy and average symbolic items. There are possibly very different factors in play for this item type. The incidence of language switching for the symbolic items is possibly associated with students simply using Persian words for the numbers, rather than any attempt at a deeper understanding of the item. It seems then, taking these results together, that the types of item that students attempt does cue quite a different response when language switching is considered, particularly when item difficulty is also considered.

Based on the results presented in Tables 4 to 7, it is clear that the students reported that they used language switching in their solution strategies across a range of item types. Although the difficulty of the item seemed to be an important issue, its impact varied in different ways for different item types. By examining the interview data, other reasons for students using language switching are revealed.

Students' Explanations for Language Switching

The analysis of the interview data, which examined where and why language switching occurred in more detail, confirmed that item difficulty was certainly one of the reasons students reported as to why they employed language switching when interpreting the text, reading particular numbers, or implementing algorithms. For example, one student (AS4) switched to Persian, when he experienced difficulty solving an average word problem involving the division of 780 by 8:

> Eight families shared a prize of $780. How much did each family receive?

In the following interview excerpt, the interviewer refers to the first named author for whom Persian is her first language and English is a second language.

Interviewer: What about this question? Also… you switched. It's very interesting that you know for this question, …this question is about family and you know to use division but just doing division appropriately is hard for you? (refer to Figure 1)

AS4: Yes, I found difficulty with division.

Interviewer: Division difficulty?

AS4: I found division hard.

Interviewer: Ah… If I change it to two digits maybe it is easier, then?

AS4: Maybe.

Interviewer: [Would] you switch into Persian if it was 2 digits… instead of seven hundred and eighty, it was seventy eight … [AS4 nodded while 78 was recorded on his worksheet]. [Would] you use Persian or no?

AS4: Yes, yes.

Interviewer: At which stage did you use Persian?

AS4: Well, in this bit I've got confused. Well, after eight divided by seventy eight [sic] to which there is nine, remainder six and I put six … to sixty [i.e., 6 tens renamed as 60 ones] and I've got confused, because I know nothing times … eight …six, …sixty, so I transferred to Persian.

Interviewer: Ah, because division in this situation is hard for you, you switched into Persian?

AS4: Yes.

His problem solving on the work sheet shows that he was unable to complete the division algorithm beyond the first step (see Figure 3). Although AS4 comprehended the question and was able to make a start, he experienced difficulty with the division algorithm, in particular, with dividing 60 by 8. He presumably switched to L1 because he could not resolve this in English.

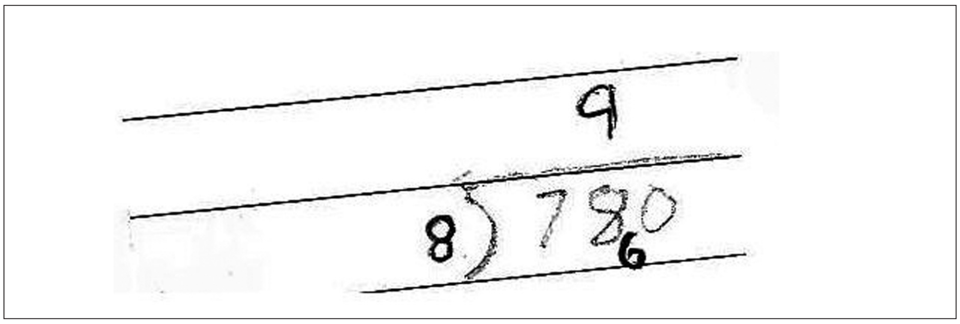

Figure 3. AS4's work sample.

The students' responses to the interviewer's questions about language switching revealed that some students switched to L1 when reading particular numbers and/or words. This seemed to be because they were used habitually when students were using Persian, and hence the students were very familiar with them. For instance, one of the students (NM5) when solving a hard open-ended question switched to L1 due to familiarity with a certain word used habitually in Persian. The problem was:

> Half of the people in a family are males. Could you draw a picture of what this family might look like?

The following interview excerpt shows the switch to Persian:

Interviewer: Okay. In this question I see you switched in Persian. Could you please explain in which step?

NM5: When I was reading, I read it in English but when I was drawing it because they are boys or males, … boys and males and … one of them that I was writing … girl, … because it was half half … and when I read girls I read it dokhtar [girl in Persian] and in that step that I did [language switching].

Interviewer: When you draw girls you said in your mind dokhtar.

NM5: Yes.

Interviewer: Why did you use Persian words?

NM5: Umm … I used it because … sometimes some word that I know I just [did] because I normally use it in every day life. When I used it normally at my home or some thing. I said like *dokhtar* because I use it normally. It's like in my head now and whenever I see it … I will think of *dokhtar* or girl.

This student regularly used the word *dokhtar* for girl in Persian, so switched to L1 when it arose in this context. She stated that she often used a mixture of English and Persian in her everyday interactions, for example, when talking on the telephone, or speaking with her parents or brother. This suggests that her language switching in this instance was prompted by her habitual use of particular words in Persian, which may or may not have anything to do with her engaging cognitively with the mathematics of the question.

In some cases, students said that being interviewed in a Persian language school and/or in the interview environment triggered the incidence of language switching. For instance, some students suggested that being in the Persian school reminded them of Iranian people and/or an Iranian custom related to the context of the word problem, such as purchasing an Iranian CD or an Iranian birthday party. This in turn led to language switching as L1 would have been used in these situations. This point is illustrated with respect to a hard word problem involving time. The problem was:

> Anna's birthday party will start at 12:45 pm. It is now 10:50 am. How much longer does Anna have to wait?

The following excerpt is from the interview with student NK5.

Interviewer: When you did this question, and you got this answer, did you use Farsi?

NK5: Ah, yeah. Because today is my birthday, and I am in the Persian school and I just used them.

Interviewer: For which word? Could you please give me an example in Persian?

NK5: tavallod [birthday in Persian]

Interviewer: Did you say tavallod, when you got the answer?

NK5: Yes.

There was evidence that being in the interview environment also prompted language switching. For example, SZ4 switched to the L1 in an average word problem involving addition. The problem was:

> Sahar had 26 books. Her brother had 37 books. How many books did they have altogether?

The following excerpt is from the interview with student SZ4.

Interviewer: I see you in your checklist form you used Farsi. Yes? And you switched into Farsi. Could you explain where you used Farsi? Which word or which number did you use Farsi for or switch languages?

SZ4: I used it for the whole sum. I used for 6, 7 and 23 (230)

Interviewer: All of them?

SZ4: Yeah.

Interviewer: Why?

SZ4: Um… because I thought I'm doing [it] in Iranian for a change.

Interviewer: For a change?

SZ4: [Nodded].

Interviewer: Why do you mean 'for a change'?

SZ4: Because I always do it in English, and then I just want to do it in Iranian (Farsi).

Interviewer: Now, for today you want to change, are making a change?

SZ4: Yeah.

Interviewer: When you do homework at home, mathematics homework, sometimes do you like to do this changing?

SZ4: For what school? English or Iranian?

Interviewer: English?

SZ4: No.

Interviewer: At home, when you do at home?

SZ4: No.

Interviewer: For example, when you do mathematics homework at home, for example, you have 10 questions or 12 questions?

SZ4: [Nodded].

Interviewer: Mathematics question and you are starting and solving them one by one, yes. Do you like to do changing, to make the changing in your way, changing to use Farsi?

SZ4: No.

This suggests that SZ4 switched to the L1 due to the interview situation as her response to the questions at the end of interview showed that she often used English for mathematical problem solving and on other occasions such as with her friends and at home. In addition, her parents indicated that they supported her in English at home when they helped her with a mathematical assignment. Given this, it is highly unlikely that she used L1 routinely to solve mathematical questions, which suggests that she switched to L1 purely as a consequence of being in the interview environment.

In summary, five students suggested they switched between their languages when solving mathematical items because of the difficulty they were having with this process, another five seem to switch because of other reasons, and the remaining four students had a mixture of reasons, one of which was difficulty.

Discussion

The key questions related to this study were:

1. Did this particular group of Iranian non English background (NESB) students report that they switched languages when solving mathematical problems?
2. What factors prompted language switching (if any) with this sample of Iranian bilingual students?

In this study 14 out of 16 Iranian NESB students reported that they switched to their L1 for at least one item when solving mathematical questions. This finding is consistent with the results of studies conducted by Clarkson and Dawe (1996) and by Latu (2005) in that all students used their L1 in doing mathematics for at least some of the time. The following sections discuss some of the possibilities explored in this study as to what prompted the language switching of the students.

Item Type and Item Difficulty

Based on the research design, three different types of mathematics questions were used in this study: symbolic items, word problems, and open-ended questions. The results of the interview analysis showed that switching between languages occurred in all three types of questions. These results suggest there is a real impact of item type on language switching, but more study is still needed on this issue.

The impact on language switching by item type was also partially dependent on item difficulty. For example, for word problems, increasing item difficulty seemed to lead to the proportion of language switching increasing. However, this proportion decreased for symbolic questions. It was speculated that the reasons why students switched languages may be dependent on item type: for word problems the language context may be an important prompt, but for symbolic items familiarisation with number words may be the critical cue. After reviewing the literature from a range of studies conducted on bilingual students, it appears there was no literature with which to compare these findings, apart from the Clarkson (1996) study which noted similar results. Those results further support the notion that there is a relationship between item type/item difficulty and language switching.

In considering the relationships between item difficulty, item type and whether students switch languages, it may be that the measure of difficulty used here is not 'fine grained' enough, and if that changed, a clearer picture may emerge. Future studies may need to concentrate more on what are the common elements that makes some items more difficult than others, irrespective of problem type. One interesting possibility to explore would be whether the cognitive load of an item, resulting in the item being more difficult than others, might evoke the use of language switching, compared to items that are deemed difficult, but is more an artefact of processing long and/or tricky repetitious algorithms.

Students' Understanding and Algorithms

Students' difficulty with the comprehension and interpretation of items prompted some students to switch to their L1. This was often related to not understanding the context of the question. For example, one student in the word problem involving time stated that he was confused between a.m. (morning time) and p.m. (afternoon time); so he used the Persian language to try and understand the question. Another student switched to her L1 when she could not understand the meaning of a question, simply saying "when I did not get it, [I] switched to Farsi [Persian]".

In this study some students experienced difficulty in implementing an appropriate strategy/algorithm, particularly for items involving division and subtraction. For example, one student switched to Persian when he carried out division involving decimals, in the hope that this would make it easier. Previous studies did not focus on students experiencing difficulty with specific algorithms, just mentioning difficulty with implementing algorithms. Further exploration related to specific algorithms, extending to those using calculators, would be useful.

Habitual Use of Specific Words

Another factor which prompted language switching for these Iranian NESB students was their familiarity with some numbers and/or words in Persian, which were used habitually at home. In some cases, students were helped with mathematical homework by their parents or a tutor who used Persian, or a mixture of Persian and English. As a consequence, these students were more likely to be familiar with the use of the Persian in a mathematics context, so they used their Persian quite habitually when attempting the mathematical item. For example, interpreting certain numbers in English, such as three, seven, and nine, or expressing some operational signs such as for subtraction (-) or multiplication (x) for some students was difficult. However, expression of *seh* instead of three, *haft* instead of seven, *noh* instead of nine, *bere*, or *bebar*, or *menha* instead of subtraction and *zarb* instead of multiplication in Persian was short and easy for these students.

This suggests for some students the pronunciation of certain numbers or other mathematical words in the Persian language is simpler than in English. However, this needs further research. It also suggests that it may not be very difficult for teachers to coopt parents' support in encouraging their children to explore mathematical ideas using Persian.

Influence of Context

The physical environment, in this case the Persian language school, triggered for some students memories causing them to remember an event or Iranian custom. For example, for one student his birthday party and purchasing a Persian CD by his mother became linked to the context of a word problem. This, in turn prompted language switching. Hence, memory might play an important role in stimulating language switching for some students. Since many of these memories are likely to be associated with home and the Iranian local community, this may give an indication of how teachers may support students' use of their L1. Teachers could experiment with asking students to use their Iranian home context as a basis for developing a series of relevant mathematical problems for the class.

Another feature of the physical environment that may have encouraged students to switch from L2 to L1 concerns their involvement in the study, particularly since the interviewer was bilingual in Persian and English, mirroring the language context of the students. For example, one student stated that she always solved mathematical questions in English, however in this instance she switched to L1 "because I just want to do it in Persian … for a change". Another student switched to L1 as he explained, "I want to find if solving [a mathematical problem] in Persian is easy or in English" during the interview time. Such student reaction may be explained from the fact that students may have felt more at ease in this context with an adult Persian speaker than they did in their normal classroom.

Such an environment in the Saturday school may have implicitly given the students permission to experiment with their languages. This may point to another useful teaching resource. Adult community members who are bilingual may be encouraged to work in class with students on mathematics. This may give students the assurance they need to explore processing mathematics using their L1 in creative ways.

Summary

According to Clarkson and Dawe (1996), Australian teachers have been slow to recognise the cognitive advantages of bilingualism; nor have they recognised that bilingual students will switch between their languages, the focus of this present study. Clarkson and Dawe stated some ten years ago that "Many non-bilingual teachers, the majority in our systems, were not really aware that their bilingual students would indeed swap languages while thinking about their class work" (1996, p. 154).

The findings from this study certainly suggest that another group of NESB students, different from those studied in the past, also use both their languages when doing mathematics, at least in an interview situation. It seems highly probable that such behaviour will occur during their time at school as well. There seems to be a variety of reasons why these students used such strategies.

It seems clear that the ease or difficulty of an item is a reason that prompts students to switch languages when doing mathematics. This seems to be an obvious linkage and is in line with what we know of students when they are faced with difficulties in learning. If their motivation is high, then they will explore many options for continuing the process. In this instance bilingual students may well explore the strategy of switching languages. In the long term this may well help them explore the different nuances of meaning found in their two languages, and hence they may come to a deeper understanding of the ideas they are learning.

However in this study we also found a number of social and cultural reasons why students may switch between their languages when engaged with mathematics. It would be easy to dismiss these as of no consequence, or at least of much lesser importance than the more obvious linkages that can be made with item difficulty. However, we would argue that this set of results is also important, although the linkage to learning is more indirect (Powell-Mikle, 2003; Seah, Atweh, Clarkson, & Ellerton, in press). In general, we do know that students bring into the classroom ideas that have been learnt elsewhere; from the playground, from friends, and most importantly from home. Part of the role of the school, and the teacher in particular, is to help students make sense of the connections between what they learn in school and what they learn out of school. For bilingual students, at least part of what they bring from outside the classroom walls will be encoded in their L1. Hence, in this study it should be no surprise that some students appeared to rely in part on what they had learnt from parents, related some of the mathematics items to their lived experiences embedded in L1 contexts in their own community, and used some Persian mathematical words which they habitually use because of their home background. We do know, in general, that when students feel comfortable and affirmed with their own situation, they have a much greater disposition for learning. For bilingual students, some of what they know, and indeed are, is embedded in a L1 social context, and some of their ideas are clearly more easily expressed in their L1. If this is acknowledged, then such students have a much better disposition to learn in their L2 (English in this context). When this affirmation is given, students may well be in a better situation to take their school learnt ideas home, and discuss them with parents and others in their L1. This then gives the students an opportunity for the continued development of their L1. Cummins (2000), it will be remembered, argued cogently that if both languages of bilingual students continued to develop together, then cognitive benefits will flow. We would argue that this should happen in mathematics sessions, just as much as in language lessons (see also Clarkson, in press). Hence, in particular, we would argue these results imply that teachers in multilingual classrooms should recognise that bilingual students may well use language switching when they attempt to solve mathematical problems. When students do switch languages it suggests that at least some of their mathematical knowledge is embedded in their L1. This is an important foundational notion for teachers as they contemplate the students they are teaching and what they bring to the classroom. One implication of these findings is that teachers of these students, and perhaps other NESB students, should consider drawing on the expertise of more competent bilingual students to support their less able peers to solve mathematics problems in L1. In this way students can more easily share mathematical knowledge that may be embedded in their first language. It might be interesting for teachers to also consider involving adult bilinguals to give NESB students implicit (and possibly explicit) language support when doing mathematics.

Acknowledgements

The authors wish to thank the students, their parents, teachers and Principals of both Persian Language Schools in Melbourne, Victoria for their willing participation in this project. We also acknowledge the involvement of Prof. Di Siemon, RMIT, the first author’s supervisor for her M Ed thesis, for which the data were originally collected. We also thank the editor and the anonymous reviewers for many helpful suggestions in polishing this article.

References

Adler, J. (2001). *Teaching mathematics in multilingual classrooms*. Dordrecht, The Netherlands: Kluwer.

Adendorff, R. (1993). Code-switching amongst Zulu-speaking teachers and their pupils. *Language and Education, 7*(3), 143-161.

Arefi, M. (1997). *The relationship between first and second language writing skills for Iranian students in Sydney: An application of the interdependence hypothesis*. Unpublished doctoral dissertation, University of Western Sydney, Nepean, Kingswood, NSW.

Baker, C. (2001). *Foundations of bilingual education and bilingualism* (3rd ed.). Clevedon, UK: Multilingual Matters.

Barwell, R. (2005). Language in the mathematics classroom. *Language and Education, 19*(2), 97-102.

Bernardo, A. B. I. (1999). Overcoming obstacles to understanding and solving word problems in mathematics. *Educational Psychology, 19*(2), 149-163.

Bernardo, A. B. I. (2002). Language and mathematical problem solving among bilinguals. *Journal of Psychology, 136*(3), 283-297.

Bernardo, A. B. I., & Calleja, M. O. (2005). The effects of stating problems in bilingual students' first and second languages on solving mathematical word problems. *Journal of Genetic Psychology, 166*(1), 117-128.

Burns, R. B. (2000). *Introduction to research methods* (4th ed.). Sydney, NSW: Pearson Education Australia.

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

Clarkson, P. C. (1991b). Language comprehension errors: A further investigation. *Mathematics Education Research Journal, 3*(2), 24-33.

Clarkson, P. C. (1992). Language and mathematics: A comparison of bilingual and monolingual students of mathematics. *Educational Studies in Mathematics, 23*(4), 417-429.

Clarkson, P. C. (1996). NESB migrant students studying mathematics: Vietnamese and Italian students in Melbourne and Sydney. In L. Puig & A. Gutierrez (Eds.), *Proceedings of the 20th annual conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 225-232). Valencia, Spain: PME.

Clarkson, P. C. (2004). Multilingual contexts for teaching mathematics. In M. J. Hoines & A. B. Fuglestad (Eds.), *Proceedings of the 28th conference of the International Group for the Psychology of Mathematics Education* (pp. 236-239). Bergen, Sweden: PME.

Clarkson, P.C. (2006). High ability bilinguals and their use of their language. *Educational Studies in Mathematics, 64*(2), 191-215.

Clarkson, P.C. (in press). Mathematics quality teaching in Australian multilingual classrooms: Developing a relevant approach to the use of classroom languages. In R. Barwell (Ed.), *Multilingualism in mathematics classrooms*. Clevedon, UK: Multilingual Matters.

Clarkson, P. C., & Dawe, L. (1994). Problem solving in two languages: A longitudinal study of bilingual students in Melbourne and Sydney. In G. Bell, B. Wright, N. Leeson & J. Geake (Ed.), *Challenges in mathematics education: Constraints on construction* (Proceedings of the 17th annual conference of the Mathematics Education Research Group of Australasia, Vol. 1 pp. 173-178). Lismore: MERGA.

Clarkson, P. C., & Dawe, L. (1996). *NESB migrant students studying mathematics: Vietnamese students in Melbourne and Sydney*. Paper presented at the Educational Research: Building New Partnerships, Joint Conference of the Educational Research Association, Singapore and the Australian Association for Research in Education, held 25-29 November at Singapore Polytechnic, Singapore.

Clarkson, P. C., & Galbraith, P. (1992). Bilingualism and mathematics learning: Another perspective. *Journal for Research in Mathematics Education, 23*(1), 34-44.

Clarkson, P. C., & Indris, N. (2006). Reverting to English to teach mathematics: How are Malaysian teachers and students changing in response to a new language context for learning? *Journal of Science and Mathematics Education in South East Asia, 29*(2), 69-96.

Cummins, J. (1979). Linguistic interdependence and the educational development of bilingual children. *Review of Educational Research, 49*(2), 222-251.

Cummins, J. (1991). Interdependence of first and second language proficiency in bilingual children. In E. Bialystok (Ed.), *Language processing in bilingual children* (pp. 70-89). Cambridge, UK: Cambridge University Press.

Cummins, J. (2000). Language, power, and pedagogy: Bilingual children in the crossfire. Clevedon, UK: Multilingual Matters.

Dawe, L. (1983). Bilingualism and mathematical reasoning in English as a second language. *Educational Studies in Mathematics, 14*(4), 325-353.

Ellerton, N., & Clarkson, P. C. (1996). Language factors in mathematics teaching and learning. In A. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International handbook of mathematics education* (pp. 991-1038). Dordrecht: Kluwer.

Erktin, E., & Akyel, A. (2005). The role of L1 and L2 reading comprehension in solving mathematical word problem: A case in a delayed partial immersion program. *Australian Review of Applied Linguistics, 28*(1), 52-66.

Homayooni, H. (2004). Editorial note: Iranian community in Melbourne. Golbang, *Monthly Newsletter of the Iranian Society of Victoria, 41*, 1.

Laborde, C., Conroy, J., De Corte, E., Lee, L., & Pimm, D. (1990). Language and mathematics. In P. Nesher & J. Kilpatrick (Eds.), *Mathematics and cognition* (pp. 53-70). Cambridge, UK: Cambridge University Press.

Lambert, W. E. (1977). The effects of bilingualism on the individual: Cognitive and socio-cultural consequences. In P. A. Hornby (Ed.), *Bilingualism: Psychological, social and educational implications* (pp. 15-27). New York: Academic Press.

Latu, V. F. (2005). Language factors that affect mathematics teaching and learning of Pasifika students. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce, & A. Roche (Eds.), *Building connections: Theory, research and practice* (Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia, Melbourne, pp. 483-490). Sydney: MERGA.

Lerman, S. (2001). Cultural, discursive psychology: A sociocultural approach to the studying, teaching and learning of mathematics. *Educational Studies in Mathematics, 46*(1/3), 87-113.

Linthorne, C., & Doolan, B. (2003). Success with problem solving. *Teaching Mathematics, 28*(1), 9-10.

Luke, A., Comber, B., & O'Brien, J. (1996). Critical literacies and cultural studies. In G. Bull & M. Anstey (Eds.), *The literacy lexicon* (pp. 31-44). Sydney, NSW: Prentice Hall.

Marland, P. (1987). Working on stimulated recall methodology. Paper presented at the 10th annual conference of the Mathematics Education Research Group of Australasia, Townsville.

Molyneux, P. (2004). Pride and empowerment: Bilingually educated students reflect on their learning. *Australian Language & Literacy Matters, 1*(2), 4-10.

Moschkovich, J. (1996). Learning math in two languages. In L. Puig & A. Gutierrez (Eds.), *Proceedings of the 20th annual conference of the International Group for the Psychology of Mathematics Education* (Vol. 4, pp. 27-34). Valencia, Spain: PME.

Mossenson, L., Stephanou, A., Forster, M., Masters, G., Anderson, P., & Hill, P. (2003). *Torch tests of reading comprehension*. Melbourne: Australian Council of Educational Research.

National Council of Supervisors of Mathematics (NCSM). (1989). Essential mathematics for the twenty-first century: The position of the National Council of Supervisors of Mathematics. *The Arithmetic Teacher, 36*(9), 27-29.

Ncedo, N., Peires, M., & Morar, T. (2002). Code-switching revisited: The use of languages in primary school science and mathematics classroom. In C. Malcolm & C. Lubisi (Eds.), *Proceedings of the 10th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*, Durban, South Africa.

O'Connell, S. (2000). Introduction to problem solving: Strategies for the elementary math classroom. Portsmouth, NH: Heinemann.

Padilla, A. M. (1990). Bilingual education: Issues and perspectives. In A. M. Padilla, H. H. Fairchild, & C. M. Valadez (Eds.), Bilingual education: Issues and strategies (pp. 11-26). Newbury Park, CA: Sage.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Pimm, D. (1987). Speaking mathematically: Communication in the mathematics classroom. London: Routledge.

Powell-Mikle, A. (2003). We are more than numbers: African American students' perceptions of exemplary mathematics teachers. *International Journal of Educational Reform, 12*(2), 83-96.

Schoenfeld, A. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334-370). New York: Macmillan.

Seah, W., Atweh, B., Clarkson, P.C., & Ellerton, N. (in press). Sociocultural perspectives in mathematics teaching and learning. In H. Forgasz, Barkatsos, A. Bishop, B. Clarke, S. Keast, P. Sullivan, W. T. Seah, & S. Willis (Eds.), *Research in mathematics education in Australasia 2004-2007*. Rotterdam: Sense Publications/MERGA.

Setati, M. (1998). Code-switching in a senior primary class of second language mathematics learning. *For the Learning of Mathematics*, *18*(1), 34-40.

Stake, R. E. (2000). Case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 435-454). Thousand Oaks, CA: Sage.

Swetnam, L. A. (2003). Lessons on multicultural education from Australia and the United States. *The Cleaning House*, 76, 208.

Vithal, R., Adler, J., & Keitel, C. (2005). *Researching mathematics education in South Africa*. Cape Town, South Africa: Human Sciences Research Council (HSRC) Press.

Authors

Zahra Parvanehnezhad, Science Mathematics Education Cluster, Melbourne Graduate School of Education, The University of Melbourne, Parkville, VIC 3052, Australia. Email: <zparvaneh10@yahoo.com> The research reported in this paper was carried out while the author was at RMIT University, VIC.

Philip C. Clarkson, Faculty of Education, Australian Catholic University, Locked Bag 4115, Fitzroy MDC, VIC 3065, Australia. Email: <Philip.Clarkson@acu.edu.au>