PROBLEM SOLVING IN TWO LANGUAGES: A LONGITUDINAL STUDY OF BILINGUAL STUDENTS IN MELBOURNE AND SYDNEY

PHILLIP CLARKSON
Christ Campus, Australian Catholic University (Victoria)

LLOYD DAWE
University of Sydney

This paper describes a study of the development of bilingual students in solving problems in mathematics, as they progress from year 4 to year 8. The total sample of 700 children will include Italian, Arabic, Vietnamese and Cambodian speakers with a control group of 200 English monolingals. We are particularly interested in the phenomenon of code switching during the problem solving process. What may prompt a bilingual student to switch languages? How often does it occur? Does it depend on the mathematical context? What changes might occur as the student progresses through year 4 to year 8? The project is being funded initially by a large ARC grant for two years, 1994-95. We would like to discuss the methodology and the practical problems involved in gathering the data. The paper falls into category B of the MERGA classification as an ongoing project for which feedback from participants will be solicited.

INTRODUCTION

Although Australia's migrant intake has remained reasonably stable at about 100 000 per year for the last 20 years, there has been a marked change in the origins of most immigrants. In the late 1960s well over half our immigrants were from English speaking countries. This figure has now fallen to below 25% (Bureau of Immigration Research, 1992). The 1988 Census reported that 2 220 000 or 14% of Australia's 16 million people spoke a language other than English in their home. Such changes in the immigration profile have in turn led to a major increase in the number of Non English Speaking Background (NESB) students in schools [NESB - people who were born or their parents were born in a non English speaking country]. Moreover, such students are concentrated in the larger cities.

Up until the early 1970s it was assumed by most educationists that being bilingual bestowed no advantage for school learning. Indeed it was a hindrance. It was believed that bilingual students who attempted to use both their languages in the classroom would inevitably have to contend with the confusion between the languages that would certainly ensue. This naive position, which is still promoted by some, is often the basis for opposing any attempt at using the ability to communicate in two languages in the classroom. Vigorous debate continues. During the 1960s and on into the 1970s, data started to accumulate that was at variance with the accepted view of the time(Peal & Lambert, 1962). A number of bilingual students were certainly below average in various school subjects, and yet others excelled (e.g. Skutnabb-Kangas & Toukomaa, 1976). One explanation for this discrepancy was found in a more careful stipulation of what bilingualism was. The fundamental idea advanced was that viewing bilingualism as a global state, which you had or did not have, was too gross. Finer gradings of levels of bilingualism were needed. Hence the notions of balanced bilinguals, and bilinguals learning in an additive or subtractive environment were formed (Lambert, 1977). One influential school of thought which took hold of this new approach grew out of the applied linguistic work of Cummins -see for example Cummins (1979,1991). It is within this theoretical framework which both investigators of this project completed their doctoral studies and later research work, Clarkson working with bilingual Papua New Guinea students and Dawe working with bilingual mmigrant children in England- see for example Clarkson (1992) and Dawe (1983). We now wish to build on our earlier research but in an Australian context. In particular, the inclusion of bilingual Vietnamese and Cambodian children in the study, recognises the impact of recent Asian immigration on Australian schools, and the emerging political and economic place of Australia in the Asian region.

During the last twenty years the links between language competence and mathematics learning have been a major area of research for mathematics educators (Ellerton & Clarkson, 1992). The broad pattern of this interaction is now starting to emerge for monolingual speakers. Bilingualism was recognised early in this movement as an important component, but has for various reasons not held centre stage. And yet in many ways this area of research holds out great potential for theoretical work in cognition. As well it investigates an area of great social need, particularly in Australia given the many NESB students in our schools, and the accepted philosophy that competence in mathematics is an important social skill for a liberally educated person. As well, there is the economic argument that we need more mathematically literate citizens for our nation to become or remain competitive.

Few studies have taken up the specific issue of mathematical competence of NESB students in Australia. A large study conducted by the ACER into school performance in the 1970s (Hewitt 1977) reported that students who had at least one parent born outside of Australia, and in addition in their home either no English or another language as well as English was spoken, had performances that were significantly poorer than their peer group of monolingual English speakers. Hewitt also noted that there seemed to be an important interaction between competency in reading English and mathematics performance. Another study which impinged on this area showed that year 5 and 6 students who were born in a non English speaking country, or both their parents were, performed less well on a mathematics test than other students, although the difference was only significant for the grade 6 students (Ainley, Goldman & Reed, 1990). Commenting on this unexpected result, the authors suggest that the grade 6 mathematics test was more dependent on language skills than the grade 5 test. It should be noted that in both of these studies no account was taken of language competence in either language of the bilingual students.

Pickering & Szaday (1990) commenting on the performance of LOTE students in Australia note that "The overall picture is piecemeal. ... If we are genuinely interested in the progress of LOTE background students through the literacy and mathematics programs of our schools, we need to institute a series of tightly controlled longitudinal surveys. The existing literature does not provide this information" (p.128).

First Aim

The first aim of this project will be to confirm that the level of competence in each language that a bilingual has will effect their performance on mathematical tests. It seems important to us that although there is evidence from overseas (including our own work) which supports this notion, this should be confirmed within an Australian setting. We will work with several important linguistic groups in our schools, Italian, Arabic, Cambodian and Vietnamese. Dawe worked with Italian children in his earlier research, although in England, and hence some interesting comparisons may be possible. We believe that work with the other three groups of students in this type of investigation has not been carried out before. However, unlike the few earlier studies in Australia which made no distinction on the basis of language, but simply treated NESB students as a group, we believe it important to treat such groups separately in the first instance to gain any other insights that may be pertinent to each culture.

Second Aim

The second specific aim that will be pursued is that of students switching between languages. We have both independently noticed in earlier research, that bilingual students regularly switched languages when attempting to solve mathematical problems. The contrasting situations of England and PNG is interesting. It was not possible to follow this matter up in any depth in those projects, although we both came to the conclusion that this could be an important factor in a bilingual student's attempt at processing mathematical problems. We would also note that although there have been many studies and much speculation on the role of code switching in general (for a number of

studies in various settings see Bialystok (1991)), there seems to be none in relation to mathematics learning. We therefore believe that that this investigation will be breaking new ground from a theoretical perspective. There will also been direct practical implications for the teaching.

The first question to ask is, do these NESB students in an Australian context switch languages when attempting mathematical questions, and if so with what frequency? If in fact switching does occur, and as we suspect quite frequently, then a number of important sub questions follow. Switching in fact may be more of a hindrance to the solution process, since there is the possibility that errors of translation may occur. Do students who respond in this way to mathematical questions make more errors than other students? What does the student do if there is no, or only an inadequate, word in their first language for an idea presented in the second language?

Another set of sub questions deals with what prompts students to switch languages. There are a number of possibilities including the following. Do students simply have a preferred language in which they wish to work when it comes to mathematics? This may occur because they habitually use their first language in most situations except when in the classroom, or quite specifically they may be helped with homework or tutored outside of the classroom in their first language. A further possibility deals with the perceived difficulty of a problem. Does this prompt students to switch languages? Certainly anecdotal evidence from one group of students that Clarkson worked with in PNG seemed to suggest this with students first using English, then Melanesian Pidgin, and then if still unsuccessful their own village language (although one suspects that the last was of little use in most cases). A third possibility seems to be a rich situation to explore, that of the mathematical context. Will there be a variation if students are confronted with symbolic algorithmic items, with routine mathematical word problems, or with open ended mathematical questions? The answers will have important implications for teaching and learning mathematics.

Third Aim

The final aim of this project is to collect a set of longitudinal data. We anticipate the life of the project to be some five years, although it has been funded from a large ARC grant for the first two years only. We note again the lack of longitudinal data that Pickering & Szaday (1990) alluded to, and the assumption often made that results from one year level will often hold for a range of levels. We anticipate that by year 8 of schooling a student's reliance on their first language will have gradually lessened, but there would still be a measurable residual effect. Further it may be that the frequency of switching may lessen as students gradually respond to mathematical problems in English because they come to believe that this is 'the' language of school work, including mathematics.

RESEARCH PLAN, METHODS AND TECHNIQUES

Subjects

Five groups of year 4 students will be involved in this study (N=700). Experimental groups will be NESB Vietnamese, Cambodian, Arabic and Italian students. The Asian language groups are important groups within the Australian society as a whole, and becoming more so as the pattern of immigration continues to change. There is a substantial grouping of Vietnamese in both cities, but the individual groups for Sydney and Melbourne were determined by ease of access for the researchers, and the demography of the schools. We have a very interesting spread across significant languages which also allows for comparison between the urban centres. The Italian group is primarily for theoretical comparison, although this language is significant in its own right. A monolingual English speaking group of students will form a control group (Table 1).

TABLE 1: Distribution of sample: M (Melbourne) and S (Sydney); N=700

EXPERIMENTAL GROUPS		CONTROL GROUP
ASIAN	EUROPEAN (other than English)	
200 x Vietnamese (M & S)	100 x Italian (M)	200 x English(M & S)
100 x Cambodian (M)	100 x Arabic (S)	

If there are too many monolingual English language students in the classes tested, a selection process using random number will be implemented. All students included in the study will have completed all their schooling in Australia. This stipulation is included since some immigrant students who have completed little schooling in their home country are sometimes started in higher grades when admitted to an Australian school because of considerations to do with age. Such students may well introduce extraneous effects.

Schools that have at least 20% of two of the target groups will be identified and the sample drawn from them. This will help minimise any school effects which may be accentuated if schools with a high proportion of one target group and few members of the others were used. We anticipate 20 schools will be used (12 in Melbourne and 8 in Sydney) although the determining factor will be obtaining 700 appropriate students.

Year 4 students have be chosen since a longitudinal format for the study will be followed. It is planned to visit students again when they are in years 6 and 8. We expect no more than a 10% loss rate from years 4 to 6 and 30% between 6 and 8.

Instruments

Language Comprehension Tests. Comprehension tests in the target languages will be devised using a cloze format. In our past studies this format has be found to be most appropriate. Two types per language will be used; one in a general narrative style, and the other in which a story outlining a mathematical situation is developed with key mathematical words and or symbols ommitted.

Mathematical Tests. Three formats will be used in devising a range of tests. The first will consist of algorithmic symbolic items. The second will have a range of mathematical word problems often favoured by primary and junior secondary teachers to indicate the brighter mathematical students. Hence these items have an extra operational importance in the classroom context. The third test will draw on 'open question' items that Sullivan and Clarke (1992) have explored. Such items do not have one right answer and hence may well present the students in this study with mathematical situations that are quite novel to them.

Student Information Sheet. An additional sheet will be attached to the back of each test instrument. Information on which language was used to process each item will be asked for. This strategy has been used before with students and with an adequate introduction, a global indication of language use can be established.

Interview Schedule. NESB students will be interviewed in a 1-1 situation and a schedule will be devised to guide this. The interview will be video taped. During the interview students will be asked to solve 3 unseen mathematical word problems and 3 novel mathematical problems. Students will be asked about the language they used for different parts of the solution process. They will also be

asked about words that would be difficult to translate directly into their first language. Finally students will be asked, using a five point scale, in what ratio of their languages do they prefer to do their thinking when completing mathematical problems (ie. all L_1/no L_2 through to no L_1/all L_2). Data obtained in the interview will provide a check for the information obtained from the 'Student Information Sheets', enable some knowledge to be gained as to whether particular stages of the solution process are more frequently attacked using code switching, as well as case by case information allowing an enriched insight into the use of language to be carried out.

Parent Background Data Sheet. Parents will be asked to fill out a sheet giving information on parental occupations both in Australia and in their home countries (home country occupations may be a better indicator for an SES variable), parental education levels, and educational expectations for their children. Such variables have proved useful in our past studies. As well information on year of arrival in Australia, common languages spoken in the home, and languages used if helping with school related assignments will also be requested.

School Records. Valuable data on children's age, previous academic performance and teachers' general knowledge of the children will be sought. However we wish to identify the social and cultural context in which the children are learning, so data about the nature of the school itself and the impact of State Government policy on the school will be important background information.

Analysis

Analyses of covariance will be used to test whether bilingual students' competencies in their languages affect mathematical scores. On the basis of the language tests, the experimental groups will be divided into three groups; students who are deemed competent in both their languages, students who are deemed to be competent in only one of their languages, and a third group who lack competence in both their languages. It is hypothesised that students competent in both their languages will outperform other groups on mathematical tasks, with students who lack competence in their languages having the lowest mathematical scores of all. Students dominant in one of their languages will occupy an intermediate position with monolingual students.

Three different mathematical scores will be used as dependent variables; a score from an algorithmic/symbolic test, a score from a test of word problems, and a score from a test composed of open ended items. Covariables included in the analyses will be various SES measures, sex (cultural practices treating boys and girls differently may well be influential), and frequency of use of the student's first language at home.

The number of items for which students report using their first language will be used as an index of code switching.

It will be expected that students will have a higher frequency of code switching as the difficulty of items increases. To test this hypotheses item difficulties from the three mathematical tests will be computed. These will be correlated for each test with the index of code switching.

In moving through the different types of mathematical situations it is anticipated that the frequency of use of the first language will increase as the more open a task becomes; that is symbolic items will prompt less code switching and the novel tasks the greatest with word items intermediate between the two. To tests this hypothesis an analysis of variance will be computed.

Correlations between the index of code switching and the students' stated preference ratio for using their languages, and the frequency of use of the first language in the home as reported by parents will also be computed. It is anticipated that the higher the frequency of use of the first language in the home, and the more a student says they want to use their first language, then the higher will be the index of code switching.

It is anticipated that analysis of the students' attempts at solving the one step mathematical problems in the interview situation will show that they use code switching more often in the initial stages of the solution process when they are coming to grips with understanding what the problem requires. In Newman's (1983) categories, when they are reading and comprehending the problem. In attempting the novel problems it is anticipated that students will return to a code switching strategy as they have to think through the next step in the process.

The longitudinal character of the study is very important. When students are in Grade 6 a similar set of data collection and subsequent analyses will be carried out. It is anticipated that although the same relationships will be evident as in grade 4, the effects of the first language will be less. Hence it is anticipated that students will use code switching strategies less often.

REFERENCES

Ainley,J., Goldman,J., & Reed,R. (1990). *Primary schooling in Victoria.* Hawthorn: Australian Council of Educational Research.

Bialystok,E. (Ed.) (1991). *Language processing in bilingual children.* Cambridge: Cambridge University Press.

Bureau of Immigration Research (1992). *Immigration update: June quarter.* Canberra: Australian Government Publishing Service.

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

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: Cambridge University Press.

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

Ellerton,N., & Clarkson,P.C. (1992) Language and mathematics. In B.Atweh & J.Watson (Eds), *Research in mathematics education in Australasia 1988-1991* (pp.153-178). Brisbane: Mathematics Education Research Group of Australasia.

Hewitt,R. (1977). School performance of students from other ethnic backgrounds. In S.Bourke & J.Keeves (Eds.), *Australian studies in school performance* (Vol. 3, pp.179-194). Canberra: Education Research and Development Committee.

Lambert, W. (1977). The effects of bilingualism on the individual: Cognitive and sociocultural consequences. In P. Hornby (Ed.), *Bilingualism* (pp.15-27). New York: Academic Press.

Newman,A. (1983). *The Newman language of mathematics kit.* Sydney: Harcourt, Brace, Jovanovich.

Peal, E. & Lambert, W. (1962). The relation of bilingualism to intelligence.*Psychological Monographs, 76,* 1-23.

Pickering,D., & Szaday,C. (1990). *One in eleven revisited.* Melbourne: Victoria College of Advanced Education.

Pickering,D., Szaday,C., & Duerdoth,P. (1988). *One in eleven: Special educational needs of Catholic schools in Victoria.* Melbourne: Victoria College of Advanced Education and Catholic Education Office of Victoria.

Skutnabb-Kangas, T., & Toukomaa, P. (1976). *Teaching migrant children's mother tongue and learning the language of the host country in the context of the socio-cultural situation of the migrant family.* Helsinki: The Finnish National Commission for UNESCO.

Sullivan,P., & Clarke,D. (1992). Problem solving with conventional mathematics content: Responses of pupils to open mathematical tasks. *Mathematics Educational Research Journal, 4*(1): 42-60.