TEACHING & LEARNING
RESEARCH INITIATIVE
NĀU I WHATU TE KĀKAHU, HE TĀNIKO TAKU

PO Box 3237
Wellington, New Zealand
e-mail: tlri@nzcer.org.nz

Pip Neville-Barton & Bill Barton

The Relationship Between English Language and Mathematics Learning for Non-native Speakers

This project was undertaken to better understand the relationship between English language and mathematics learning for students for whom English is an additional language (EAL). We were interested in exploring the extent of any difficulties in learning mathematics attributable to low proficiency in English language, and also discovering particular language features that might cause problems.

Some literature that explores this issue at the elementary level exists, but there is little work at the senior secondary or tertiary levels. In New Zealand, many of the EAL students arrive in our education system in the final years of secondary school or directly into tertiary institutions.

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Project Aims

- To examine the impact and nature of language factors in the learning of mathematics for EAL students.
- To produce recommendations for mathematics teachers of EAL students.
- To produce guidelines for the design of language support programmes.
- To develop a group of teachers with an interest in language and mathematics and the skills to continue researching this issue.

The research questions were:

1. What is the extent of the disadvantage in mathematics learning due to low English language proficiency at the senior secondary and university undergraduate levels?
2. What specific language features cause difficulty for particular groups of senior and undergraduate EAL students learning mathematics, and how do these compare with language difficulties experienced by first language (L1) students?
3. What is the relative importance of technical language knowledge compared with general language proficiency in the learning of mathematics at senior secondary and undergraduate levels?
4. What awareness do secondary and undergraduate EAL students have of the difficulties they face due to low English proficiency?
5. What practical steps can be taken by teachers in mathematical learning environments to ameliorate language effects; and what support services can be provided by educational institutions?

The study involved an initial research design team of five practitioners with research experience, each from a different institution, and a research co-ordinator from a sixth institution. The design team comprised successful, active mathematics teachers who had had some contact with university postgraduate programmes. Each member of the team co-opted other teachers from their institutions. Each group undertook an independent study in their institution, although the topics were closely related under the project aims, and some research instruments were shared.

Although all the studies had both scientific and investigative features, three of the studies were primarily investigative. One examined an area of mathematics and mathematical discourse not previously studied (proof and argumentation in third-year undergraduate mathematics), a second focused on Pasifika-speaking students, using the personal experience of the Pasifika researchers, while a third made use of the applied linguistics background of the researchers to conduct in-depth interviews with Mandarin-speaking students. Two studies were primarily scientific, one using mathematically matched Mandarin-speaking and English L1 groups to discover the specific features of mathematical discourse that resulted in statistically significant differences, and the other using a bilingual research design to look closely at English-Mandarin discourse differences.

Observations, tests, questionnaires, and selected interviews were all used as data collection techniques.

Below are brief summaries of the studies conducted in each institution.

AUCKLAND GIRLS' GRAMMAR SCHOOL

This study involved 40 Years 12 and 13 Chinese Mandarin-speaking students. The project was fortunate to have a bilingual native Mandarin-speaking teacher, Jushi Hu, who was able to write parallel tests in Mandarin and English. These tests were administered in two sittings 7 weeks apart. At each sitting half the students did the English and half the Mandarin version, swapping over in the second test. The analysis focused on comparing students' performance on the Mandarin and English versions of the test. Group interviews were conducted to gather further insight into the test responses.

The study indicated that these students experienced, on average, a 15 percent disadvantage in overall performance in the English test compared to their performance in the Mandarin test. The syntax of mathematical discourse appeared to cause more problems than vocabulary. The teachers were surprised by some of the misunderstandings revealed in the interviews. There was also lower overall performance, indicating that this group of students is not as mathematically competent as expected by their teachers. Interviews revealed that some students had not had the higher level background usually associated with students from China.

WELLINGTON GIRLS' COLLEGE

This study involved 13 Years 12 and 13 Chinese Mandarin-speaking students. The test and administration paralleled that at Auckland Girls' Grammar School, with a shorter time between tests. It included a self-reporting of students' understanding of mathematical instruction. Twelve of the students were interviewed individually and in depth.

The analysis focused on the nature of their language difficulties and the strategies the students thought would help their learning.

This study confirmed the disadvantage for students when doing mathematics in English, with a difference of 12 percent on this smaller sample. The interviews revealed particular misunderstandings, a narrow understanding of some concepts, and many strategies for coping with their lack of comprehension. The students self-reported only a little difficulty on average in understanding mathematics in English, despite the problems revealed in their test performance and interviews.

MACLEANS COLLEGE

This study involved testing 135 Year 13 students from a variety of language backgrounds. The test collected demographic information and Year 12 grades, and tested mathematical syntax and vocabulary, contextual problems, and problems with redundant information. The analysis was restricted to a Chinese group (14 students) and an English group (17 students) with parallel mathematical ability based on Year 12 grades.

Only three of 32 items showed a significant difference at the 1 percent level—on all three items the English group outperformed the Chinese group. On a further six items there was a significant difference at the 5 percent level; two of these were done better by the Chinese group. No other items showed significant difference. An examination of the individual items revealed the main problems for Chinese students were prepositions, word order, and interpreting context.

TANGAROA COLLEGE

This study involved observations of two Year 12 mathematics classes, the administration of two questionnaires to the 42 Pasifika students in these classes, and interviews with 16 students. Initial observations and researcher experience led to a hypothesis that vocabulary was the most important issue for these students. The first questionnaire tested this feature, mathematical syntax, and mathematical word problems. The second questionnaire tested specific discourse features in word problems. Students received the questionnaire in English with a translation into their first language.

The study indicated that vocabulary on its own, particularly instructional vocabulary, was not as problematic as anticipated. Rather it was the combination of syntax and technical vocabulary that caused difficulties. Word problems involving implication were the hardest for the students to solve. During the interviews it emerged that low general proficiency in both languages could also be a significant factor in learning mathematics.

THE UNIVERSITY OF AUCKLAND

This study involved observation of two third-year university mathematics courses. Twelve Chinese-speaking students from one course were then asked to self-report their understanding of the course and were tested on specific mathematical items. English language proficiency results were also available for these students. Follow-up testing of two large courses was undertaken in the second semester to confirm the results and to enable a comparison with English L1 students to be made.

Significant differences were found in third-year classes compared with first-year ones, in that mathematical understanding was much more deeply embedded in the language of the lecturer and texts. The result of the initial testing showed that the disadvantage experienced by the EAL students due to language is higher than expected, and was severe for those students with lower English proficiency. All students appeared unaware of their difficulties. The follow-up testing confirmed these results and indicated that the L1 students did not have any language problems.

Findings and Limitations

All five studies offered quantitative or qualitative evidence that EAL students suffer a disadvantage of about 10-15 percent in mathematics learning due to language difficulties. Four of the five studies provided evidence that students do not realise the extent of their difficulties.

All studies reported that students in general performed worse than the teachers/lecturers anticipated. There was evidence from interviews that, contrary to assumptions, some students did not have the background required for senior levels of mathematics.

The language features causing difficulties varied across the studies, and appear to depend on the mathematical level as well as the home language and English language proficiency levels. Vocabulary on its own is not the big issue that was anticipated. However, it was a component of the difficulty experienced with understanding mathematical discourse as a whole.

Prepositions and word order were key features causing problems at all levels. So also were logical structures such as implication, conditionals, and negation, both at senior secondary and third-year university levels. Mathematics couched in everyday contexts caused the expected problems.

Recommendations

1. Teachers undertaking supported research, specific to their classroom and subject, is an effective mode of professional development, and should continue to be a significant part of any development programme.
2. Resources need to be allocated to supporting EAL students in this area (from Pasifika, Chinese, and many other language groups).
   - 2.1 Better understanding of these students' language and mathematics proficiency at the time they enter New Zealand classrooms—and hence better placement of these students.
   - 2.2 The development of special courses in English mathematical discourse, with particular focus on making links between mathematical discourse in the students' home language and in English.
   - 2.3 The development of in-service programmes for teachers to increase their awareness, and to give them strategies, to support EAL students in their classroom.
3. Further research in this area is warranted.
   - 3.1 Further research is needed into the mathematical discourse of Pasifika languages.
   - 3.2 Further research is needed into the relationships between Mandarin/Cantonese mathematical discourse and English mathematical discourse, and whether students' difficulties arise from these relationships.
   - 3.3 The effectiveness of courses for students designed to support their learning of mathematics in English needs to be properly evaluated.
   - 3.4 The feasibility and effectiveness of providing opportunities for students to discuss mathematics in their home language as part of the pathway to learning mathematics in English, needs to be investigated.

In conclusion, we are sure that this has been a positive involvement for the teacher/researchers, and compares extremely favourably with other professional development experiences.

Pip Neville-Barton is a Senior Lecturer at Unitec New Zealand in the School of English and Applied Linguistics. Her key areas of research interest are professional development, the effect of English language tuition on the lives of new immigrants and, more recently, research into the language of mathematics and how this affects the learning of EAL mathematics students.

Bill Barton is Associate Professor and HOD of Mathematics at the University of Auckland. He is currently undertaking research into language and mathematics, ethnomathematics, and teacher development.

Researchers & Contributing Authors

Research Co-ordinator

Pip Neville-Barton *Unitec New Zealand*

Researchers & Contributing Authors

Bill Barton, Bob Chan *The University of Auckland*

Chris King, Viliami Latu *The University of Auckland*

Bruce Dixon, Vaughan Mitchell *Macleans College*

Mark Phillips *Macleans College*

Anne Blundell, Jushi Hu *Auckland Girls' Grammar School*

Rasela Lafaele, Havili Ofamo'oni *Tangaroa College*

Sosefina Paletaoga *Tangaroa College*

Elaine Vine *Victoria University of Wellington*

Marianne Devere, Monica Luxford *Wellington Girls' College*