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Ethnic Minority Student Achievement in Mathematics in the Early School Years in Cambodian Bilingual Schools: CARE’s Riel Mathematics Research Project

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Abstract

Research investigating the cognitive effect of bilingualism on mathematical learning began just over 25 years ago and has progressed from there, although research focusing on the Asia-Pacific region is still quite limited. This paper presents details about a current project in this area. CARE’s Riel Maths research project investigates ethnic minority student achievement in mathematics by testing the hypothesis that ethnic minority students in the early school years who attend bilingual schools where the mother tongue and national language, Khmer, are the languages of instruction, are at an advantage in terms of mathematical growth compared with ethnic minority students attending Khmer language only schools. The Riel Maths Project is a longitudinal panel study with the research being carried out over 4 years, from 2009 to 2012.

Keywords: academic achievement, bilingualism, cognitive effects, ethnic minorities, mathematics

Background

In the five highland provinces of North East Cambodia there are over 100,000 Indigenous people coming from over 10 ethnic groups, commonly referred to as ‘ethnic minorities’. Most people live in remote villages with very poor or no access to health or educational services and extremely limited access to commercial activities. In Ratanakiri Province, the prominent groups are the Tampuen, Kreung, Jarai, Brov and Kavet who together make up around 57% of the 124,000 population of the province. The balance of the population is made up of Lao, Vietnamese and Chinese (13%), and Khmer (30%). The cultures and languages of the Indigenous ethnic minority groups are distinct from
mainstream Khmer culture and language. All groups in this area speak their own languages and practice their own religions.

In 2003, through the funding auspices of the Australian Agency for International Development (AusAID) CARE Cambodia's Highland Children's Education Project (HCEP) opened schools in six remote communities in Ratanakiri province with a total enrolment of 278 students, all at the Grade 1 level and 45% of whom were girls. A number of additional projects now complement the original project and significantly extend the aims of the overall enterprise. The main complementary project is known as “Bending Bamboo” which focuses on the educational needs of marginalised girls and young mothers. The Pau Ray Collins Trust Fund Initiative (PCTFI), which funds Bending Bamboo, through CARE USA, aims to make a 'lasting difference' in the lives of girls (CARE, 2007) through evidence based research into the impact of interventions. There is a convergence in both the aims of bilingual education and the aims of PCTFI. Benson (2005) lists a number of claims ‘regarding positive effects of mother tongue use on girls’ school participation’. These are that more girls enrol in school when they can learn in a language that is familiar to them; school use of the home language increases parent participation and influence allowing parents to participate in school activities and decision-making, with the resulting curriculum better meeting local needs with the effect that schooling becomes more relevant for girls; teachers from the same linguistic and cultural communities as their students are less likely to exploit female students; girls in bilingual classes stay in school longer; girls learn better and can demonstrate their learning in the mother tongue; bilingual teachers treat girls more fairly in the learning process; and, more women may become teachers, and thus role models for girls (Benson, 2005, pp. 4-5).

These projects and their activities are now collectively called the Highland Communities Program – HCP (Noorlander, 2008). By February 2008 the original 6 HCEP schools had a total enrolment of 801 (44% girls) and were staffed by 42 locally recruited and trained, indigenous community teachers. The schools are all bilingual with initial literacy being developed in one of two vernacular languages, Tampuen or Kreung, with the national language, Khmer, being taught orally in the first year then phased in as the language of instruction over the ensuing 3 years. The Program adapts the state primary curriculum to the local context incorporating life-skills that draw upon the knowledge and culture of community people.

While gaining increasing acceptance with Governments in a number of countries around the world, bilingual education remains a form of
education surrounded by misconceptions and considerable scepticism. That children would learn to read and write more efficiently and effectively when the language of instruction and the language they are learning to read and write is their own, might seem self-evident. What is less well understood is that this approach, learning the first language first, actually helps children learn a second language (the national language) more effectively than similar children who experience a form of education in the national language only. This paper explores one of the research efforts of CARE Cambodia in investigating the hypothesis that ethnic minority children receiving a bilingual education in their home language or ‘mother language’ and the national language in the early grades, grades 1 to 3, learn the national language, Khmer, better than ethnic minority children whose education is in the national language only. There will be specific attention given to the effect that this form of education has on girls in particular.

CARE Cambodia has established a longitudinal research project to test the above hypothesis. The research effort consists of three projects: (a) Oral Khmer; (b) Early Literacy Acquisition in Khmer the national language; and, (c) Mathematics, with each research project testing a sub-hypothesis of the main research effort. The latter project, mathematics, tests the hypothesis that ethnic minority students in the early school years (Grades 1-3) who attend bilingual schools where the mother tongue is the language of instruction (L1), are at an advantage in terms of mathematical growth compared with ethnic minority students attending Khmer language (L2) schools. Minnesota International Development Education Consortium (MIDEC) as a ‘critical friend’ supports CARE’s research effort. MIDEC has been engaged as partners by PCTFI to support the research efforts in 8 CARE country offices as part of the PCTFI global agenda to provide evidence about ‘what works’ to improve education for marginalised girls.

The Riel Maths Research Project

The Riel Maths Research Project investigates whether ethnic minority students in the early school years (Grades 1-3) who attend bilingual schools where both the mother tongue (L1) and the national language (L2) are the languages of instruction, are at an advantage in terms of mathematical development compared with ethnic minority students attending Khmer language (L2) only schools.

Riel Maths focuses on the topic of ethnic minority student achievement in mathematics. Ethnic minority students refer to children who ‘(a) share a culture (or ethnicity) and/or language of their own that distinguishes them from other groups of people; and (b) in terms of numbers, are fewer than the predominant group(s) of people in the given
state (Kosonen, 2005). In this research it is also assumed that the student's first language is a far more critical factor in educational achievement than ethnicity (Cummins, 2000).

Bilingualism in mathematics describes the competency to solve problems using two languages in terms of mathematical meanings, the use of mathematical language and the use of strategies, which are all tools with which students think and speak mathematically (Lerman, 2001).

Mathematical development refers to a students' development of mathematical knowledge, skills and understandings in the strands of number (incorporating the domains of counting, place value, addition and subtraction strategies, and multiplication and division strategies), measurement (incorporating the domains of length, mass and time), and space (incorporating the domains of properties of shape, and visualisation), (Clarke et al., 2002). This research also accepts that 'mathematics education is culturally dependent and specific to the environment in which it is taking place' (Ní Riordáin & O'Donoghue, 2008).

**Early Years Numeracy Research**

The literature review initially focused on recent research and research-informed projects in the Asia-Pacific region – within ten years - on two main topics: early years numeracy, and bilingualism in mathematics. There was a large number of research reports for early years numeracy research, but very little on bilingual student achievement in mathematics. Therefore, for the latter, any relevant literature, regardless of the timeframe, was included in the review.

There have been a number of major mathematics research and research-informed projects over the last ten years in the Asia-Pacific region that have relevance for this project: Count Me In Too (CMIT); Early Numeracy Project (ENRP); the New Zealand Numeracy Development Project (NZNDP); and several projects under Australian Government's 'Numeracy Research and Development Initiative', including Project Good Start, and Supporting Indigenous Students Achievement in Numeracy.

The key theoretical component of the CMIT project was the Learning Framework in Number (LFIN) initially developed for the purpose of researching and documenting progress in number learning of students in the first three years of school. An intervention program was designed based on LFIN – Mathematics Recovery which has provided the basis for CMIT in a number of ways – the learning framework, the approach to interview-based assessment, and teachers use of digital recording interviews as learning tools.
The *Early Numeracy Research Project* (ENRP) was established in 1999 as a joint venture between Australian Catholic University, Monash University, the Victorian Department of Employment, Education and Training, the Catholic Education Office, and the Association of Independent Schools Victoria, in 35 project (‘trial’) schools and 35 control (‘reference’) schools, at Preparatory Grade to Grade 2. The stated aims of the ENRP were the following to assist schools to implement the design elements as part of the school's mathematics program; to challenge teachers to explore their beliefs and understandings about how children develop their understanding of mathematics, and how this can be supported through the teaching program; and to evaluate the effect of the design elements and the professional development program on student numeracy outcomes (Clarke et al., 2002). The major elements of the research design included the development of a framework of ‘growth points’ in young children’s understanding of mathematics across a range of mathematical domains; the development of associated assessment instruments, designed to show growth across these domains, as measured by movement through the growth points (one-to-one interview, ongoing assessment tasks, formal and informal assessment techniques developed by teachers); the delivery of focused professional development; the implementation of appropriate school support structures; the monitoring of student achievement and growth over time (interviews conducted twice yearly); and the documenting of effective practice of teachers, professional learning teams and schools’ (Clarke et al., 2002). ENRP presented key findings on students’ growth; on effective teachers and schools; on children’s mathematical understandings; and findings in relation to design element approach to whole school improvement.

Much of the impetus for NZNDP government initiative came from the results of the *Third International Mathematics and Science Study* (TIMSS) which: ‘showed that New Zealand students performed poorly in mathematics compared to those of other education systems’ (Bobis et al., 2005). Although not entirely focused on the early school years, the key features of the NZNDP were a number framework that involved strategies for solving problems with numbers; a diagnostic interview which was an individual task-based instrument designed to provide teachers with information about students’ knowledge; and a professional development program that was situated in the classroom and individualised.

The Australian Government’s ‘Numeracy Research and Development Initiative’, 2003-2004 funded *Project Good Start* to investigate the practices and learning experiences that support the early numeracy development of a sample of children in the year before school and
the first year of schooling. The key questions under investigation were ‘how can effective numeracy programs be identified at both the year before school and in the first year of school’, and ‘what constitutes evidence of effectiveness?’ (Thomson, Rowe, Underwood & Peck 2005). Project Good Start profiled children’s numeracy development at the beginning and the end of their pre-school year to gauge numeracy development due to the pre-school’s program. Further numeracy profiling, at the beginning and at the end of children’s first year of school then traced children’s numeracy development in their first year of school. Project Good Start collected both quantitative and qualitative data. Two instruments were used for the quantitative data collection, and qualitative data were collected after analysis of the quantitative data. Key findings of Project Good Start focused on assessment of numeracy, numeracy learning, curriculum and professional development.

The Supporting Indigenous Students Achievement in Numeracy (SISAN) Project was also an Australian Government’s ‘Numeracy Research and Development Initiative’, 2003-2004. SISAN researched the impact that the development and implementation of authentic (rich) assessment tasks have on the outcomes of middle years Indigenous students in a targeted group of schools. Specifically, the research project aimed to develop a relatively small but representative item bank of authentic (rich) assessment tasks suitable for Indigenous students in middle years in remote non-urban schools in the Northern Territory; trial the use of the tasks by teachers in a sample of remote, non-urban schools and evaluate the impact of these tasks on student outcomes; provide recommendations for procedures for development of a more comprehensive item bank of authentic (rich) assessment tasks, and strategies for how teachers in similar schools might use such tasks to assess student outcomes and plan instruction (Department of Education Science and Training, 2005). The key findings of SISAN was that the development of authentic (rich) assessment tasks had the potential to support Indigenous students in middle years in remote communities but this ‘requires the involvement of Indigenous and non-Indigenous teachers, schools and community leaders over an extended period of time’ (Department of Education Science and Training, 2005). SISAN believed that the most important message from the research was ‘the critical importance of building remote teachers’ professional knowledge to support quality approaches to the teaching and learning of mathematics’ (Department of Education Science and Training, 2005). Although focused on the middle-school years, what is of relevance to the Riel Maths project is that two of the five schools in the SISAN Project were remote Indigenous bilingual schools.
Bilingualism in Mathematics Research

In regard to bilingualism in mathematics, there have been few research projects in the Asia-Pacific region. Research investigating the cognitive effect of bilingualism on mathematical learning began just over 25 years ago (Dawe, 1983; Clarkson, 1992), and has progressed from there, although research focusing on the Asia-Pacific region is still quite limited.

Gale, McClay, Christie, & Harris (1981) conducted research to test the hypothesis that bilingual education produces better academic results than monolingual education in a second language. The research was a three year longitudinal quantitative study (1976-1979) in Years 5, 6 and 7 of a bilingual program in a remote Aboriginal community in the Northern Territory, Australia. The children were tested in Oral English, Reading, English Written Composition, and an Arithmetic Test. The same test was also given to English-only classes. Their research showed that there was little difference between the English-only and the bilingual children in their addition ability; that the bilingual children were superior to English-only children in subtraction; and, that bilingual children performed significantly better than English-only children in multiplication and division.

Clarkson (1992) conducted a quantitative study comparing mathematics achievement between a bilingual group and a monolingual group in PNG. The aims of Clarkson's project was to ascertain whether bilingualism has a debilitating affect on a student's learning; and, to test the linguistic theory that the level of competence a bilingual person has in each language is important in mathematical performance. The quantitative study was undertaken in PNG in the early 1990s. Two groups of students: a bilingual group (n=232) in year 6 from five primary schools in Lae; a monolingual group (n= 69) in year 6 from two international schools in Lae. Children were tested using two different mathematical instruments -- one, a general test drawing on a broad range of content, and the other a test of mathematical word problems. Clarkson's research findings confirmed that bilingual students who had low competence in both languages were disadvantaged compared with other groups; and, that competence in both language can bring advantages for bilingual students in the classroom.

The literature shows that in the Asia-Pacific region there has been little research into bilingualism in mathematics, particularly in South East Asian countries.

Research Question

The Riel Maths project explores the following question: do ethnic mi-
nority students in the early school years (Grades 1-3) who attend bilingual schools where the mother tongue is used as the principal language of instruction, have the same mathematical growth to that of ethnic minority students attending state schools where Khmer language is used as the sole language of instruction?

**Research Design**

Prior to finalising the research design, two Khmer researchers, one Kreung research assistant, and one Tampuen research assistant, all funded through the PCTFI initiative, were trained in the research process. The Australian principal researcher, who worked with the researchers and research assistants, received funding from an Australian Government Endeavour Research Fellowship. This allowed for the research proposal and the research design to be negotiated in the field with CARE Cambodia staff.

The *Riel Maths* Project is a longitudinal panel study with the research being carried out over 4 years, from 2009 to 2012. *Riel Maths* will use a continuous interval panel, whose members will complete data collection activities at one period each year over four years. The quantitative data source are ethnic minority students who speak Kreung or Tampuen as their first language and attend Bending Bamboo target bilingual schools (n=50) and HCEP bilingual schools (n=50); and ethnic minority students who speak Kreung or Tampuen as their first language and attend state schools where Khmer language is used as the sole language of instruction (n=50). The students are in their early school years (Grade 1 in 2009), and are drawn from a number of state schools in the Ratanakiri Province of Cambodia.

The measurement instrument is modelled on ENRP Assessment Interview (Clarke et al., 2002), the major data collection instrument for the ENRP. Rather than focusing on growth points though, the *Riel Maths Assessment Interview* measure students’ mathematical knowledge, skills and understandings in the strands of number, incorporating the domains of counting, place value, addition and subtraction strategies, and multiplication and division strategies; measurement, incorporating the domains of length, mass and time; and, space, incorporating the domains of properties of shape, and visualisation). The *Riel Maths Assessment Interview* is cross-referenced with Cambodia’s Ministry of Education, Youth and Sport (MoEYS) maths curriculum to ensure curriculum validity.

The data collection interview consists of 43 authentic (rich) assessment tasks (Figure 1). The tasks are considered as authentic (rich) as they connect to some aspect of the students’ experiences, allow all stu-
dents to make a start, support a range of different solution strategies and/or correct responses, and have the potential to reveal something of the students' mathematical skills and thinking (Clarke & Clarke, 1998). In the first interview students continue with the tasks step-by-step in each section until an error is recorded. In the subsequent rounds of data collection they commence the interview at the first item in each section that was recorded as an error.

Figure 1: Example of data collection interview item

![Example of data collection interview item](image)

Q18. A farmer at the market sells some milk fruit for 95000 riel, some papaya for 16000 riel, and some bananas for 25000 riel. How many riel does she have?

SPSS is used for data management and data analysis to ensure that the quality of collected data is adequate, that data are turned into useful information, and that data management problems are avoided. A feature of the data analysis is that data will be disaggregated by gender, which will provide useful information on the issue of bilingual education and education for girls. The research has received ethical clearance from Australian Catholic University's Human Research Ethics Committee, complies with CARE's Bending Bamboo Projects' Ethics and Procedures Manual, which includes community approval and consent, and has support and approval from the Ratanakiri Provincial Office of Education.

Data collection

The data collection instrument was designed and then trialled in two bilingual schools and one state school. The trial involved three girls and two boys of whom three were Kreung speakers and two were Tampheun. Two students were from Grade One, one from Grade Two and two from Grade Three. After each interview, items were reviewed and if required revised, replaced or discarded. Any new items were included in the next interview.

The trial data was then examined during a two-day workshop in Phnom Penh with 'critical friends' from the Minnesota International Development Consortium to ascertain its usefulness and to make any required adjustments to the database. At this meeting the timetable
for data collection activities was confirmed, and preparations were finalised.

The first two rounds of data have been collected, one in 2009 and the second round in 2010, with 300 assessment interviews conducted (Fig 2). Data has been entered, but at the time of writing there has been no preliminary analysis. The next two data collection rounds are scheduled for June/July 2011 and 2012, with data analysis and reporting scheduled for early 2013.

**Figure 2: Data collection interview. Photo: Jack Frawley**

![Data collection interview](image)

**Conclusion**

As international development organizations embrace more evidence-based practice, they are undertaking increasingly rigorous and sophisticated efforts to assess the impact of their interventions. This paper has described one of the three research projects being conducted by CARE Cambodia in undertaking quasi-experimental research and evaluation of its early grade bilingual education interventions in rural Cambodia. Student performance in bilingual classrooms is being compared with that of students in conventional, Khmer only government schools in the rural Ratanakiri Province of Cambodia. Research investigating the cognitive effect of bilingualism on mathematical learning began just over 25 years ago and has progressed from there, although research focusing on the Asia-Pacific region is still quite limited. The *Riel Maths* research project on its completion will make a significant contribution to the literature.
Note
1 Riel is the currency of Cambodia and is used here to emphasise authentic (real) maths tasks and accompanying resources that informed the data collection instrument.

References


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students learning through the medium of Irish Educational studies in mathematics.

