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2. MATHEMATICS EDUCATION AND LANGUAGE DIVERSITY

Past, Present and Future

INTRODUCTION

There is a growing body of research on mathematics education and language diversity and increasingly this research is published in international mathematics education journals as well as linguistics journals focusing on language and education. The first journal paper on mathematics and language diversity to be published in an international mathematics education journal appeared in 1979. The paper, entitled "Language and mathematical education", was authored by Austin and Howson and published in Educational Studies in Mathematics (ESM). ESM is the oldest English international mathematics education journal, which was first published in 1968. An interesting question to ask is why the first journal paper on mathematics and language diversity was only published in 1979.

This Chapter provides a brief review of research on mathematics and language diversity internationally. The review focuses on research published in selected key international journals and was guided by the following questions:

- What research has been published in this area of study internationally?
- What contribution has this research made to our understanding of the complexities of teaching and learning maths in contexts of language diversity?
- What are the gaps and silences visible in research in this area?

The phrase language diversity is used to refer to contexts in which any of the participants (learners, teachers or others) are potentially able to draw on more than one language as they go about their work. The presence of these languages, however, does not necessarily mean that language diversity is recognised as an asset in that context. I deliberately use the phrase language diversity rather than bilingualism or multilingualism to highlight the significant differences between what I refer to as the politics of bilingualism and politics of multilingualism. While multilingualism is about inclusion and recognition of all languages, bilingualism is about competition between two languages to the exclusion of others. In all the contexts that are labelled as bilingual there is an existence of other languages that are wittingly or unwittingly silenced. For a detailed discussion on this matter see Phakeng (forthcoming).

A. Halai & P. Clarkson (Eds.), Teaching and Learning Mathematics in Multilingual Classrooms, 11–23.

I begin this Chapter with a discussion of research on language and learning published before 1979. What follows is a brief background on how this discussion began in mathematics education. Here I highlight the important role that the second International Congress on Mathematical Education (ICME-2) held in the United Kingdom in September 1972 as well as the international symposium on "Interactions between linguistics and Mathematical Education" held in Kenya in 1974 played in shaping the debates. While the review presented in this Chapter does not include conference papers, I specifically focus on these two conferences because they gave the impetus for the Austin and Howson paper published in ESM in 1979. These discussions provide a theoretical context for what follows: a description of the methodology used for the review and an analysis of research done in this area of study internationally. From these bases I highlight gaps and possibilities for future research.

Setting the Scene: Research on Language and Learning before 1979

While the first paper on mathematics education and language diversity was only published in 1979, there were extensive debates among researchers and educators about the effects of bilingualism on the learner before then. Many of these debates happened in psychology journals and books (e.g., Child development) while there was silence in mathematics education journals. There are authors who argued that bilingualism has negative effects on language development, educational attainment, cognitive growth and intelligence (Reynold, 1928; Saer, 1963 both cited in Grosjean, 1982). Others argued that under certain conditions bilingual skills can have positive effects on the learning process (Ianco-Worrall, 1973; Been-Zeef, 1977; Pearl & Lambert, 1962).

A great majority of studies completed before 1979 concluded that bilingualism had negative effects on learners' linguistic, cognitive and educational development. Bilingualism was seen as unnatural and it was argued that a bilingual child hardly learns either of the two languages as perfectly as he would have done if he had limited himself to one. There was also a widespread view that the brain effort required to master two languages instead of one diminishes the child's power of learning other things, which might and ought to be learned. Leo Weisgerber (1933 in Saunders, 1988), a highly regarded German linguist, argued that bilingualism could impair the intelligence of a whole ethnic group, while Reynold (1928 in Saunders, 1988) was concerned about the fact that bilingualism leads to language mixing and language confusion which in turn results in a reduction in the ability to think and act precisely, a decrease in intelligence, an increase in lethargy and reduced self-discipline. From his study of Welsh-English bilingual children in rural areas Saer (1923) concluded that bilingual learners had lower IQ scores than monolingual children, and this inferiority became greater with each year from age seven to eleven. Saunders (1988) warned, however, that caution must be exercised when comparing monolinguals and bilinguals on tests of intelligence, particularly on the tests of verbal intelligence,

and particularly if, as often happens, the bilinguals are tested in only one of their languages, perhaps the second language.

It was in 1962 when Pearl and Lambert conducted a study that indicated that bilingualism is an asset to the child. They studied the effects of bilingualism on the intellectual functioning of ten year-old children from six Montreal schools. They found that instead of suffering from 'mental confusion' bilinguals were profiting from a language asset. They concluded that:

> Intellectually (the bilingual's) experience with two language systems seems to have left him with a mental flexibility, a superiority in concept formation, and a more diversified set of mental abilities, in the sense that the patterns of abilities developed by bilinguals were more heterogeneous. It is not possible to state from the present study whether the intelligent child became bilingual or whether bilingualism aided his intellectual development, but there is no question about the fact that he is superior intellectually. In contrast, the monolingual appears to have more unitary structure of intelligence, which he must use for all types of intellectual tasks. (Pearl & Lambert, 1962, p. 20)

Although these results were criticised on the grounds that only the intellectually brighter children were chosen for the bilingual group (e.g., by Macnamara, 1966), the studies that followed also indicated that bilingualism is an asset. Ianco-Worrall's (1972) study of Afrikaans-English four to nine year-old bilingual children in South Africa showed that bilinguals reach a stage in semantic development two or three years earlier than their monolingual peers. They analyse language more intensively than do monolinguals. Been Zeef (1977) found the same results in a similar study with Hebrew-English bilinguals and monolingual English and Hebrew children. Bilinguals realise sooner the arbitrary nature of language because the link between a word and its meaning is less strong in bilinguals than in monolinguals. This result had some implications for the bilinguals' cognitive abilities. As Cummins (1981, p. 33) argued, the ability to separate the meaning of a word from its sound is necessary if a child is to use language effectively as a tool for thinking.

In 1979, Swain and Cummins compared the positive and negative studies and concluded that the positive findings are usually associated with majority language groups in immersion programs. In such cases there is a high value attached to knowing two languages. The second language is added at no cost to the first and the parents are of relatively high socio-economic status. Negative findings, on the other hand, are found with submersion students who are surrounded by negative attitudes. They are forced to learn the majority language and are not encouraged to retain their first language. They also do not live in a social environment that is conducive to learning. Swain and Cummins also argued that while there were a variety of factors impacting children's intellectual development, bilingualism was one of the significant factors that could have a positive impact. While research in this area of study at this stage did not foreground the role of the social, it is clear that there was an acceptance that it is possible that bilingualism per se might have

no necessary effects (either negative or positive) on the cognitive and intellectual development of children in general. What may account for the contradictory results reported in the literature during this period are the psychosocial differences between bilinguals and monolinguals, and not bilingualism per se.

The Beginning of the Conversation in Mathematics Education Journals

During the second International Congress on Mathematical Education (ICME-2) held in the United Kingdom in September 1972, the need for fundamental research on the relationship between the learning of basic mathematical structures and the language through which they are learnt was highlighted as critical. It was as a result of this ICME-2 decision that an international symposium on "Interactions between linguistics and Mathematical Education" was held in Nairobi, Kenya from 1st to 11th September 1974. The symposium was sponsored by UNESCO in cooperation with the International Congress on Mathematical Instruction (ICMI) and the Centre for Educational Development Overseas (CEDO). Prior to 1974, it seems that there were no formally organised international conferences focusing exclusively on the relationship between mathematics and language. The Symposium highlighted the lack of research on the relationship between language and mathematics and concluded that difficulties in mathematics learning depend on the language of learning. It further affirmed that all languages include linguistic features of benefit for the acquisition of mathematical concepts and thus can be used for mathematics teaching and learning.

One of the issues that the symposium highlighted is the fact that the problems of learning mathematics in an additional or foreign language are not peculiar to learning in a world language such as English or French because there are many other countries such as Tanzania and India, where many learners have to learn mathematics in a national language (e.g., Kiswahili, Hindi) which is not their home language. This practice still continues and increasingly so in European countries that do not have any of the now world languages as the main language (e.g., Spain, Italy) and are experiencing the pressure to ensure that their learners are fluent in at least one of the world languages. In my view this is an important matter that remains a gap in research in this area of study. So far research published in the selected journals focuses on bilingual and multilingual contexts and not yet on the specificity of trilingual contexts where learners are exposed to a home language, national language and official language. The specificity of trilingual contexts in mathematics teaching and learning lies in the fact that unlike in multilingual contexts where there is a presence of multiple languages but only two languages (home language and LoLT) that are in competition, learners in trilingual contexts have to deal with three languages, each of which has its own power and influence – one as a home language, the second as a national language and the third as a world language.

The paper published by Austin and Howson in Educational Studies in Mathematics in 1979 was a follow up on the Nairobi symposium and it concludes

that the challenge of language and mathematics learning and teaching is not just an issue for developing countries but for the whole world. In developing countries the challenge is that of learners learning mathematics in a language that is not their mother tongue; in developed countries such as Wales, the USA, Belgium and Canada there are communities of immigrants with well-established 'minority' languages and in some countries there are instances where problems arise because of the non-standard nature of the local vernacular (e.g., Jamaica, England, USA, etc.). Austin and Howson acknowledged the fact that bilingualism is a political matter and thus change in society may lead to policy change. Indeed much has changed since 1979: the world has become more multilingual and some countries have changed their language policies and practices, which makes this review timely and relevant. The section that follows focuses on the methodology used in this review – essentially, where and how relevant research published was identified.

METHODOLOGY

Research on mathematics and language diversity is published in mathematics education journals as well as linguistics journals focusing on language in education. In completing this review it was thus important to consider journals across these disciplines. Focusing specifically on published research in journals means that other research that is completed on mathematics and language diversity was excluded because it is not published in the selected journals. The decision to focus only on research published in specific journals was influenced by the need to pay attention only to work that has gone through a rigorous process of review and published in generally recognised leading journals in mathematics education international.

In identifying papers focusing on mathematics education and language diversity, there were also papers focusing broadly on different aspects of language and communication in mathematics education, for example work of Pimm, Pirie, Morgan, Rowland and others. These papers are excluded from the review because they do not focus specifically on language diversity in mathematics education, but on the nature of the mathematical language or ways of communicating mathematically. The Table 1 provides details of the journals selected for the review, the year of inception of the journal as well as the number of papers identified as relevant for the review.

The main limitation of this methodology is that it covers only international journals that only publish in English and thus excludes authors who do not write in English as well as research conducted in regions where English is not the language of research. Table 2 shows how the number of publications has increased per decade since the seventies.

Most of the research completed in this area of study is empirical and the data is analysed qualitatively. The section that follows explores the content of the research that has been published, its contribution as well as the gaps and possibilities for future research.

Table 1. Details of journals selected for the review

	Name of Journal	*Year of inception*	*Number of papers*
Mathematics Education Journals	Educational Studies in Mathematics (ESM)	1968	18
	Journal of Research in Mathematics Education (JRME)	1970	6
	For the Learning of Mathematics (FLM)	1980	8
	Mathematics Education Research Journal (MERJ)	1989	9
	International Journal of Science and Mathematics Education (IJSME)	2000	2
	Sub-Total		43
Linguistics Journals	Journal of Multilingual and Multicultural Development (JMMD)	1980	0
	Language and Education	1987	5
	International Journal of Bilingual Education and Bilingualism (IJBEB)	1998	2
	International Journal of Multilingualism (IJM)	2000	1
	Sub-Total		8
Total			51

Table 2. The number of papers published per decade

Period	*Number of articles published*
1970 – 1979	1
1980 – 1989	6
1990 – 1999	11
2000 – 2009	25
2010 – 2012	8
Total	51

REVIEW OF RESEARCH IN THIS AREA OF STUDY

Table 3 tabulates the most dominant topics or themes that the research has focused on. In order to systematise the review of the papers I developed a framework for looking at the papers. I looked at the journal in which the paper is published, the author, level (i.e., primary/secondary/tertiary), central problem, research approach and the arguments the paper is making. This enabled me to look across the papers and it also made visible the themes and trends emerging from the review. While on the surface it may seem unproblematic to decide which paper focuses on one theme rather than another, in practice the distinctions were more complex. So in deciding on the theme I focused more on the central problem that the paper is addressing rather than issues that come up in the process of the exploration. For example, while Moschkovich (1999) refers to the practice of code-switching, the central problem that the paper is exploring is how teachers can support the participation of English Language Learners in mathematical discourse.

Table 3 shows in brief what research has been undertaken in this area of study. It is not surprising that learner performance has the highest number of papers published because the concern with the performance of learners who learn mathematics in a language that is not their home language is at the core of most of the research completed in this area of study. As I argued elsewhere, at the core of this concern is the need to address the uneven distribution of mathematical knowledge and success (see Setati, 2012). Studies that focused on learner performance compared the performance of learners who learn mathematics in their home language and those

Table 3. Research topics covered in the papers published

Research topics/themes	*Number of papers*		
	Mathematics Ed Journals	*Language journals*	*Total*
Code-switching	8	3	11
Teachers supporting bilingual or multilingual learners	6	0	6
Learner performance	18	3	21
Curriculum planning & Development	4	0	4
Policy	1	1	2
Learner participation	1	1	2
Conversation between researchers from the north and the south	2	0	2
Research Methodology/theory	2	0	2
Research Review	1	0	1
Total	43	8	51

who learn in a language that is not their home language. Research concluded that poor performance is due to lack of understanding the language of the test (Adetula, 1989; De Courcy & Burston, 2000; Evans, 2007; Farrell, 2011; Llabre & Cuevas, 1983; Ni Riodan & Donoghue, 2009; Zepp, 1982). What we have learned from this research is that for the performance of learners who learn mathematics in a language that is not their own to improve it is important that the language, culture and the logic or reasoning system of the learner should match with that of the teacher, the textbook and the curriculum (Berry, 1985; Evans, 2007; Zepp, 1982). Recent research suggests that competence in both the home and the language of learning and teaching (LoLT) can be an advantage in mathematics achievement (Clarkson, 1992; Clarkson & Galbraith, 1992). While Farrell (2011) and Gerber, Engelbrecht, Harding, and Rogan (2005) caution that causal relationships should never be assumed when it comes to the relationship between language fluency and learner performance; he agrees with Clarkson that competence in the home language and the LoLT has a bearing on learner performance. These findings encourage bilingualism and in many ways are at odds with those of the sixties, which positioned bilingualism as a problem.

Research in this area of study does not only encourage bilingualism but also argues for the development of the learners' home languages as a strategy to motivate them to succeed in mathematics (e.g., Barton, Fairhall, & Trinick, 1998). While encouraging the development and the use of the home languages may be an ideal for many countries, it is due to the hegemony of what is regarded as the language of power (e.g., English) that the use of code-switching to support learners has become a common practice in many classrooms all over the world (Adler, 1998, 1999; Barwell, 2003a, 2005; Clarkson, 2007; Heng, 2006; Khisty & Chval, 2002; Lim & Presmeg, 2010; Moschkovich, 1999; Planas & Setati, 2009; Setati, 1998; Setati & Adler, 2000, Setati, 2005). This is mainly because teachers are trying to ensure that while they use the learners' home languages to support learning they do not disadvantage their learners by not ensuring that they have access to English, which is seen as a language of international communication.

The research theme/topic that has the least number of papers in Table 3 is the one on reviews. This is because there has not been a review since the 1979 paper by Austin and Howson that provides a bibliography indicating the wide variety of relevant articles and books in this area of study. The other categories that have fewer than five papers published are the category on research methodology/theory, north-south conversations, policy issues and learner participation. The first paper in the category on methodology/theory highlights the fact that research in mathematics education is mainly published in English and discusses how this may discriminate on the basis of language use both within the community of researchers and in the practice of research (Barwell, 2003b). Discrimination here refers to differential opportunities afforded for using language with resultant effects of unequal access to power and resources. Barwell (2003b) observes that most of the research in

mathematics education is carried out in multilingual settings and thus the languages and the language practices in such settings influence findings of the research even if it is not exploring issues of language.

What is most interesting is the fact that the two publications that focus on issues of language policy are both based on the Malaysian experience (Heng & Tan, 2006; Lim & Presmeg, 2010). These papers are as a result of the language policy changes that happened in Malaysia, which implemented its new education policy of teaching mathematics and science in English in 2003 in a move to keep abreast with global developments and have greater access to science, technology and business knowledge. The research was mainly to understand the impact that this new policy has on classroom practice and to find out how teachers were dealing with the challenges of teaching mathematics in English. Given the recent (2011) switch again in Malaysia on language policy, it might be anticipated that further studies will be undertaken to track its impact on learning and teaching mathematics. It is interesting that while policy changes also happened in several countries in Africa during the nineties none of the papers focusing on policy were published in the linguistics and mathematics education journals selected for this review.

The papers in the north-south conversations category focus on interactions between researchers in South Africa, Britain and the USA about language diversity issues in mathematics education (Barwell & Setati, 2005; Phakeng & Moschkovich, 2013). The papers specifically compare how some mathematics teachers and learners in the different countries deal with the complexities of learning and teaching mathematics in linguistically diverse classrooms. On the one hand, Barwell and Setati (2005) foreground code-switching as a common practice in multilingual classrooms in South Africa, but it is never used in UK classrooms. On the other hand, Phakeng, and Moschkovich (2013) raise two important issues that until then had not been attended to by research in this area of study. First, is the fact that while research in this area of study refers explicitly to language and culture, it does not foreground race. There is no doubt that language plays an important role in the social construction of race, racism and racial identity in mathematics classrooms and thus interesting that research in this area of study has ignored these important links in its analyses. The second issue is the fact that research in this area of study in the USA refers to bilingualism despite the multilingual nature of the country and the classrooms. While the political agendas of bilingualism are different from those of multilingualism, it is clear that research in this area of study uses the two labels as a proxy for race and socio-economic status.

It is perhaps important at this stage to indicate that research in this area of study has tended to treat bilingualism as a form of multilingualism, which is convenient but problematic because it ignores the different political agendas of bilingualism and multilingualism. It is often true that in contexts that are regarded as bilingual are in fact multilingual but foreground two dominant traditions that are in competition. For example Canada is regarded as a bilingual country, with English and French

as official languages, despite the fact that there are indigenous people who speak a variety of languages that are never counted. A bilingual language policy is often used as an apparatus of politics to appease two competing language traditions. These politics inevitably shape language choices, and language use in mathematics classrooms in these countries. It is Adler (1997, 1998, 1999) and Setati (1998) who introduced multilingual mathematics classrooms through their publications, which came out in the nineties. This move has also shaped the thinking in this area of study internationally.

What Are the Gaps and Silences Visible in Research in This Area?

While research in this area of study conducted in the USA and Europe involves immigrant learners, most of it does not focus on the specificity of this group of mathematics learners. In my view this is a weakness because as Planas and Gorgorio (2004) argue, challenges faced by immigrant mathematics learners in linguistically diverse classrooms are different from those faced by other learners. While the challenges faced by other learners may be limited to language fluency, immigrant learners also have to deal with issues of cultural, political and linguistic identity. As Kazima (2007) argues, in addition to language, learners bring different cultural practices that are relevant for their mathematics learning. Thus to focus only on how the language of their new country shapes their mathematics learning does not give a full understanding of the challenges that immigrant learners have to deal with. Furthermore, research conducted in developing countries has so far not focused much on immigrant learners and thus gives an impression that immigrant learners are only a feature of mathematics classrooms in developed countries, while in fact there are immigrant learners all over the world.

There is a dearth of research in this area of study focusing on teacher education. Only two papers were identified as focusing on teacher education, however, were not categorised as such because the focus of their analysis was not on how the teacher educators support their learners (Stacey & MacGregor, 1991; Chitera, 2009). While the participants in Chitera's research (2009) were teacher educators the paper essentially focused on code-switching as a practice in teacher education classrooms, hence it was listed under code-switching. The second paper focuses on immigrant pre-service teachers in Australia with limited English language skills (Stacey & MacGregor, 1991). The authors highlight these teachers' limitations when teaching mathematics in English and then argued that they need to be provided with opportunities to develop and improve their language skills during teacher education.

While research in this area of study continues to grow, very little of it focuses on how mathematics teachers should deal with the complexities of teaching and learning mathematics in linguistically diverse classrooms. While research focuses on the analysis of what currently is, teachers on the ground continue to hope and ask for what could or should be. Herein lies another opportunity for further research.

CONCLUSION

This paper has given an overview of research in mathematics and language diversity. It has specifically focused on the development of research on mathematics education and language diversity, highlighting significant advances, findings, gaps and future research directions. It has further highlighted not only the paucity but also the slow growth of research in this area of study – 51 papers were published in the selected international journals between 1979 and 2012. This is clearly a slow growth that also signal the small number of researchers worldwide working in this area of study. Elsewhere I have argued that this area of research is politically charged with inter-disciplinary demands as well as the need for multilingual research teams. This is perhaps what accounts for the slow growth and hence the challenges are not just about growing knowledge in this area of study but also about growing capacity.

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