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BETWEEN LANGUAGES AND DISCOURSES: LANGUAGE PRACTICES IN PRIMARY MULTILINGUAL MATHEMATICS CLASSROOMS IN SOUTH AFRICA

ABSTRACT. In this paper we draw on two research projects in South Africa to describe and discuss the language practices of teachers in primary multilingual mathematics classrooms. We focus particularly on code-switching – moving across languages and discourses. We situate the paper in the policy and practice environment of post-apartheid South African education in which code-switching is encouraged. Through our descriptions and discussion, we argue that while at a general political and pedagogical level it makes sense for teachers to encourage and use code-switching as a learning and teaching resource, this is not a straight forward matter. We argue that different English language infrastructures present primary mathematics teachers with different challenges for communicating mathematics. Furthermore, we show how the movement across mathematical discourses relates to movement between languages in classroom communication.

INTRODUCTION

What does it mean to learn and teach mathematics in a primary classroom where there are a relatively large number of learners (35+), and the teacher and all the pupils are multilingual[1] but none have the language of learning and teaching (LOLT) as their main language? Such is the situation in the majority of urban classrooms in South Africa. What does it mean to learn and teach mathematics in a rural primary classroom in South Africa, where classes are more likely to be bilingual and even larger, but English as target language and LOLT is only heard, spoken and written in the formal school context? How is mathematical learning enabled and constrained in such complex linguistic sites? Embedded in these questions are theoretical and pedagogical questions about language and learning, and language and mathematics and political questions about language-in-education policy.

In this paper, we will draw on our research experience in bi-/multilingual primary mathematics classrooms in South African to explore these broader questions. In particular, we will focus on a long established practice in multilingual mathematics classrooms in South Africa: code-switching. Code-switching in a school classroom (and we discuss this in more detail below) usually refers to bilingual or multilingual settings, and at its most general,

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entails switching by the teachers and/or learners between the LOLT and the learners' main language. Code-switching is a practice that enables learners to harness their main language as a learning resource. As a mechanism for learning and access, code-switching has almost become a taken for granted 'good thing'. It makes immediate sense that learners whose main language is not the LOLT should draw on their main language(s) in the learning process. However, it is often that which makes most sense that is most elusive to critical interrogation.

We begin the paper with a discussion of developments and research in relation to code-switching in multilingual mathematics classrooms and then relate this specific language practice to a wider analysis of the complex dynamic of teaching and learning mathematics in multilingual settings. These provide a theoretical context for what follows: a description and analysis of two recent research projects in South Africa, each related to language practices in multilingual primary mathematics classrooms in different ways. From these empirical and theoretical bases we draw out two key arguments both of which illuminate the complexities of code-switching as a resource in and for learning in school. Firstly, the political and pedagogical issues in rural and urban multilingual mathematics classrooms in South Africa are different, and this *contextual diversity* needs to be recognised in language-in-education policy, research and practice. Secondly, moving between languages (e.g. English and isiZulu) is only part of the process of learning mathematics in multilingual classrooms. There are numerous, distinct mathematical discourses that require navigation at the same time. *Moving between languages and discourses* in moments of practice is a significant challenge for mathematics education research and practice. These arguments arise out of the South African context and have specific relevance in the current educational debates in South Africa. Multilingual mathematics classrooms are, however, an increasing urban phenomenon in many other countries. We believe that the issues raised in this article are thus of relevance in the wider mathematics education community.

CODE-SWITCHING AND THE LEARNING AND TEACHING OF MATHEMATICS IN MULTILINGUAL CLASSROOMS

Debate on the effects of bi-/multilingualism on the learner goes back decades. We will not rehearse these here as they have been described in detail elsewhere. Some authors maintain that bi-/multilingualism has negative effects on language development, educational attainment, cognitive growth and intelligence (Reynold, 1928; Saer, 1963 both in Grosjean, 1982). Others argue that under certain conditions bilingual skills can have positive effects on the learning process (Ianco-Worrall, 1973; Ben-Zeef, 1977, Bialystok, 1987, Doyle, 1978, Pearl and Lambert, 1962 all in De Klerk, 1995).

The complex relationship between bi/multilingualism and *mathematics* learning has long been recognised. Dawe (1983), Zepp (1989), Clarkson (1991) and Stephens et al. (1993) have all argued that bilingualism per se does not impede mathematics learning. Their research has drawn extensively on Cummins' (1981) theory of the relationship between language and cognition. Cummins distinguished different levels and kinds of bilingualism, and showed a relationship between learning, levels of proficiency in both languages, and the additive or substractive model of bilingual education used in a school. Secada (1992) has provided an extensive overview of research on bilingual education and mathematics achievement, and pointed to findings of a significant relationship between the development of language and achievement in mathematics. In particular, oral proficiency in English in the absence of mother tongue instruction was negatively related to achievement in mathematics. This field of research has, however, drawn much criticism, largely because of its cognitive orientation and its inevitable deficit model of the bilingual learner (Martin-Jones and Romaine, 1986; Frederickson and Cline, 1990 both in Baker, 1993, p. 144). The argument is that school performance (and by implication, mathematics achievement) is determined by a complex of inter-related factors. Poor performance of bilingual learners thus cannot be attributed to the learner's language proficiencies in isolation of wider social, cultural and political factors that infuse schooling.

We agree with this line of criticism. We nevertheless read into this earlier cognitively oriented research, an implicit argument for support of the maintenance of learners' main language(s), and, so too, the potential benefits of learners drawing on their main language(s) in their mathematics learning. As Secada (1991) has argued, bi-or multilingualism is becoming the norm in urban classrooms, rather than the exception. Hence the need in mathematics education research to examine classroom practices where the bi/multilingual speaker (as opposed to the monolingual speaker) is not only treated as the norm, but his or her facility across languages is viewed as a resource rather than a problem (Baker, 1993). In an article entitled 'The bilingual as a competent specific speaker-hearer' Grosjean (1985, p. 471) argues for a bi-/multilingual (or holistic) view of bi-/multilingualism in any consideration of bi-/multilinguals. This is different from the monolingual view, which always compares the linguistic ability of bi-/multilinguals with that of monolinguals of the languages concerned. Bi-/multilinguals have a unique and specific language configuration and therefore they should not be considered as the sum of two or more complete or incomplete monolinguals.

> The coexistence and constant interaction of the two languages in the bilingual has produced a different but complete language system. An analogy comes from the domain of athletics. The high hurdler blends two types of competencies: that of high jumping and that of sprinting. When compared individually with the sprinter or the high jumper, the hurdler meets neither level of competence, and yet when taken as a whole, the hurdler is an athlete in his or her own right. No expert in track and field would ever compare a high hurdler to a sprinter or to a high jumper, even though the former blends certain characteristics of the latter two. In many ways the bilingual is like the high hurdler. (Grosjean, 1985, p. 471)

In Grosjean's terms, language practices in bi-/multilingual classrooms should not necessarily be the same as those language practices in monolingual classrooms i.e. classrooms where the LOLT is the main language of all the learners and the teacher. For example, an important aspect of bi-/multilingualism, that which makes the bi-/multilingual person an integrated whole, is code-switching (CS). CS, or switching from one language to another in the course of a conversation, can be expected to occur in bi-/multilingual settings. Martin-Jones' (1995) review of research on code-switching in the bi-/multilingual classroom reveals the shifting emphases and growing understanding of the complexity of this language practice.

Code-switching as a learning and teaching resource has been the focus of a range of studies in mathematics education in the recent past (e.g. Adler, 1996, 1998; Arthur, 1994; Khisty, 1995; Moschovich, 1996, 1999; Setati, 1996, 1998). These studies have either demonstrated and/or argued for use of the learners' main language in teaching and learning mathematics as a support needed while the learners continue to develop proficiency in the language of learning and teaching (LOLT), at the same time as learning mathematics. All of these studies have been framed by a conception of mediated learning, and of the communicative and cognitive functions of speech. Learners need to talk to learn, and such talking to learn is a function of fluency and ease in the language of communication. In other words, talk is understood as a social thinking tool (Mercer, 1995). It is thus not surprising that problems arise when learners' main languages are not drawn on for talking to learn. Arthur's study in Botswana schools revealed that the absence of appropriate use of learners' main language, and a delivery of instruction through English only, subtracted out opportunities for exploratory talk, and thus for meaning-making. Teaching-learning communication was restricted to what she called 'final draft' utterances in English, seemingly devoid of meaning. Arthur argued that this effect was a function of both the teacher and the learners not having the opportunity for talking to learn (through a main language) and hence for conceptual exploration through more informal language forms.

The dominance of English in multilingual classrooms is not unique to Botswana. Indeed, English as LoLT continues to dominate in South Africa's multilingual classrooms, despite new progressive language-in-education policies (Taylor and Vinjevold, 1999). The post apartheid constitution in South Africa officially recognises 11 languages (9 African languages, and English and Afrikaans). Language-in-education policy promotes choice over language of learning and teaching as well as language(s) as subject. There is, moreover, strong advocacy, again at a policy level, for an additive model of multilingualism, and for related language practices like code-switching in the classroom (DoE, 2000). English, nevertheless, remains the language of government and economic exchange, and hence the language of access and power. That teachers continue to focus on and use English as LoLT (with the concomitant undervaluing of learners' main languages that ensues) in their multilingual classrooms needs to be understood in this context and in terms of what teachers might perceive to be in the best interests of their learners. As we have argued elsewhere (Setati, Adler, Reed and Bapoo, in press), the dominance of English in South Africa is not easy to resolve. Any study of language practices in multilingual classrooms requires an understanding of these political dimensions.

So far we have presented arguments for harnessing learners' main language(s) as a resource in the teaching and learning of mathematics in multilingual classrooms. We have also briefly pointed to the political difficulties teachers face in multilingual contexts when one language is inescapably dominant. Neither of these discussions, however, illuminate the specific challenges of teaching and learning mathematics in multilingual classrooms.

Learning and teaching *mathematics* in a bi-/multilingual classroom where the LOLT is not the learners' main language is complicated. Learning mathematics has elements that are similar to learning a language since, mathematics, with its conceptual and abstracted forms, has a specific register and set of discourses. It is to this that we now turn.

> Mathematics . . . teachers . . . face different kinds of challenges in their bi- /multilingual classrooms from English Language teachers. The latter have as their goal, fluency and accuracy in the new language – English. Mathematics . . . teachers, in contrast, have a dual task. They face the major demand of continuously needing to teach both mathematics and English at the same time. (Adler, Slonimsky and Lelliott et al., 1997, p. 17)

Learners, on the other hand, have to cope with the new language of mathematics as well as the new language in which mathematics is taught (English). They are also attempting to acquire communicative competence in mathematical language where learning to articulate the meaning of certain concepts involves the development of a language that can best describe the concepts involved. This is especially pertinent to mathematics because mathematical talk is known for involving both specialised terms and different meanings attached to everyday words i.e. a specific register.

We can also understand mathematical language, particularly as it is used in the school context, as comprising both informal and formal components.[2] Informal language is the kind that learners use in everyday life to express their mathematical understanding. Formal mathematical language refers to the standard use of terminology (mathematics register) which is usually developed within formal settings like schools. In most mathematics classrooms both forms of language are used and these can be either in written or spoken form. Pimm illuminates the challenges this poses for mathematics teachers:

> One difficulty facing all teachers, however, is how to encourage movement in their learners from the predominantly informal spoken language with which they are all pretty fluent, to the formal language that is frequently perceived to be the landmark of mathematical activity. (Pimm, 1991, p. 21)

In bi-/multilingual settings, the challenge becomes a three dimensional dynamic (Adler, 1996, 1998). It simultaneously entails access to the language of learning (English in the South African or USA context), access to mathematical discourses, and access to classroom discourses. There are ways of speaking English, of talking within and about mathematics, and of talking in school. The dynamic is given interesting illumination by Moschovich (1999) in her study of discourses in a primary mathematics classroom in the USA where most learners were Spanish-speakers. Through her analysis of classroom transcripts, Moschkovich (1999) is able to show the significant effects of practices like 'revoicing' by the teacher. Here, in the whole class setting, the teacher is able to listen to and work with learners' informal or incomplete mathematical language productions and revoice and so frame them towards appropriate or more formal mathematical discourses. In this way, the teacher enables access to English, mathematical English, and ways of talking mathematics in school. The teacher understands her role as including the modelling of mathematical talk for learners who are struggling simultaneously with concepts and their appropriate naming in English, the language of learning and teaching.

In addition, *mathematics* in school is itself carried by distinctive discourses. Cobb (1998), for example, has distinguished calculational from conceptual discourses in the mathematics classroom. He defines calculational discourse as discussions in which the primary topic of conversation is any type of calculational process, and conceptual discourse as discussions in which reasons for calculating in particular ways also become explicit topics of conversations (Cobb, 1998: 46). To elaborate: most learners come into the school with informal ways of talking mathematics. The challenge that teachers face is to encourage movement in their learners from the predominantly informal spoken language to formal written mathematical language, and this includes both conceptual and calculational discourses. In mathematics, informal language can be referred to as the kind that learners use in their everyday lives to express their mathematical thinking. For example, learners, in their everyday life, may refer to a half as any fraction of a whole and hence can talk about dividing a loaf of bread into 'three halves'. This is inappropriate in formal mathematical talk. In addition to initiating learners into the formal mathematical meanings and use of 'half', and the conceptual discourse of fractions as equal parts of a whole, learners also need to learn how to use calculational discourses that enable operations on and manipulations of fractions.

In most mathematics classrooms both informal and formal language are used and these can be either in written or spoken form. The valued goal in school mathematics classrooms is formal, written mathematical competence. Pimm (1991) suggests that there are two possible routes to facilitate movement from informal spoken language to the formal written mathematical language. The first route is to encourage learners to write down their informal utterances and then to work on making the written language more self-sufficient. The second is to work on the formality and self-sufficiency of the spoken language prior to its being written down (Pimm, 1991, p. 21).

In bi-/multilingual classrooms the movement from formal spoken language to formal written language is complicated by the fact that the learners' informal spoken language is typically in a language that is not the LOLT. As the diagram below shows the movement from informal spoken to formal written mathematics in multilingual classrooms is at three levels: from spoken to written language, from main language to English and from informal to formal mathematical language. The different possible routes are represented in Figure 1 by different lines. For instance, one route could be to encourage learners to write down their informal utterances in the main language, then write them in informal mathematical English and finally work on making the written mathematical English more formal. In this case the teacher works first on learners' writing their informal mathematical thinking in both languages, and thereafter on formalising and translating the written mathematics into the LOLT. The other possibility is to work first on translating the informal spoken mathematical language into

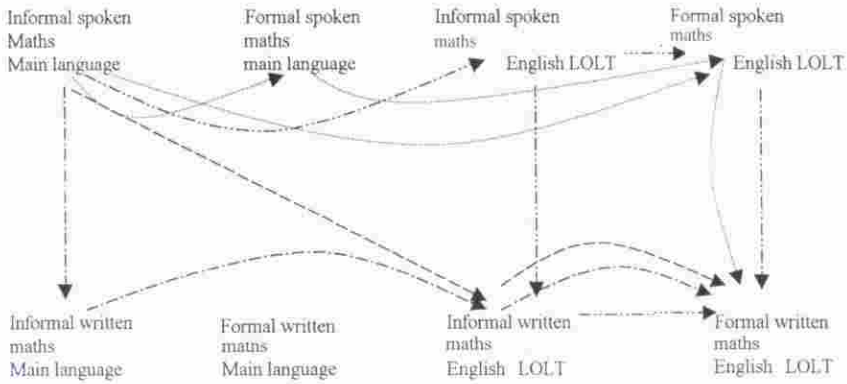

Figure 1.

spoken English and then work on formalising and writing the mathematics. There are of course other possible routes that can be followed in this diagram.

As can be seen in the diagram, while formal written mathematics in the learners' main language(s) is a possibility, there are a variety of reasons why most multilingual teachers would not work on formalising spoken and written mathematics language in the main language:

- the mathematics register is not well developed in most of the African languages,
- due to the dominance of English this would be seen/interpreted as a waste of time

In the remainder of the paper we are going to describe and analyse two different studies each of which investigated code-switching practices in primary mathematics classroom settings in South Africa. In the description and analysis, our attention will be on how teachers and learners navigate between the power of English as LOLT, and the pedagogical significance of learners' main language(s) as a learning resource. The first study illuminates the complex demands on CS as a practice across diverse linguistic contexts. The second, through its closer focus on mathematical practices, illuminates how teachers and learners navigate between languages and discourses and so the issues involved in moving between informal spoken mathematics (in the main language) and formal written mathematics (in English).

WORKING ACROSS CONTEXTS

In 1996, the University of the Witwatersrand introduced an in-service teacher development programme: the Further Diploma in Education (FDE) in Mathematics, Science and English Language Teaching. At the same time a research project was launched with the aim of investigating teachers' 'take-up' from this programme. Central to the research project and the substance of this paper is the understanding of a teacher as working with resources (including languages) in context. The data on which we draw here were collected in ten rural and urban, primary and secondary schools in the Northern Province and Gauteng,[3] in which a selection of the 1996 cohort of FDE teachers were working. Each of the teachers in the sample was visited for one week in each of three successive years (25 teachers in 1996, 23 in 1997 and 18 in 1998, with the numbers changing as a few teachers were transferred or dropped out of the programme or were working in contexts where schooling was disrupted). The data include transcribed interviews with each teacher for each of the three years, teacher narratives and responses to questionnaires, observation schedules and notes from the lessons observed, videotapes of some of the lessons, examples of learners' work. Methodologically, while the research project has 'project evaluation' elements to it, it is more appropriately described as a practice-based (Lampert and Ball, 1998), case study of cases (Bassey, 1999). The FDE is the overall case, with the teachers constituting a collection of particular cases. The research aimed to learn from teachers' about their classroom practice, but with the focus on the relationship between this practice and the practices in the FDE programme (Adler and Reed, 2000; Adler, Lelliott and Slonimsky, 1997; Adler, Lelliott and Reed, 1998).

Of the 12 primary teachers in the research project, 5 were mathematics teachers, 4 of whom were located in poor rural schools, and the fifth in a semi-urban school. Of the 4 secondary teachers, 2 were in relatively poor rural schools, and 2 were in Soweto, an urban, if under-resourced environment. English was an additional language for all the teachers and all their learners in all of these schools. As mentioned in the introduction to this paper, in rural schools, although teachers and learners tend to share the same main language, they learn and teach in a context where there is a very limited English language infrastructure. Typically, English is only heard, spoken, read and written in the formal school context. Elsewhere (Setati, Adler, Reed and Bapoo, forthcoming) we have described this linguistic environment as a *foreign language learning environment*. In contrast, in more urban environments, teachers have the added complexity of having to work with learners who bring a range of main languages to class, but at the same time there is a more substantial English language infrastructure in and around the school, and hence a linguistic context that is more supportive of English as LOLT. We have called these environments *additional language learning environments*.[4] In these diverse contexts, and as discussed above, mathematics teachers face the double challenge of teaching their subject in English while learners were still learning English.

The discussion so far of the language-in-education policy environment in South Africa, research and development with regard to code-switching as classroom practice, and the demands of learning mathematics in a multilingual context, enables us to see complex and competing demands on primary mathematics teachers in multilingual contexts in South Africa. They are to embrace an additive model of bi/multilingual learning and at the same time, deal with the dominance of English and so demand for access to English. They also need to enable talking to learn, exploratory or informal mathematical talk which invariably needs to take place in learners' main language(s), or in a combination of those languages and the LOLT constituted by code-switching. At the same time they are to provide learner access to mathematical discourses, and in particular assist learners to develop formal written competence in mathematical English. The pedagogical and the political are inextricably intertwined in each of these. And in moments of classroom practice, they can pull in competing and contradictory ways.

A progressive policy environment such as we currently have in South Africa is a necessary but insufficient condition for progressive practice. Moreover, language-in-education policy is general policy. It does not deal in any explicit way with what might be different in primary as opposed to secondary school contexts, or across schools with different linguistic infrastructures. It also does not deal with specific subject learning. With English as target language in South African schools, code-switching practices are not only inevitable but necessary in the mathematics classroom. But what is the form and substance of such practices in urban and rural primary mathematics classrooms, and what might be their pedagogical and political effects, particularly with the pressure on teachers to push the use of English in school?

In line with current education and language-in-education policies, the FDE programme's approach to the multilingual context in which teachers work, has been to encourage code-switching as a means for enabling learners to talk more freely in class, and so to use their main language as a learning resource, for talking to learn. In the research project we were interested to see to what extent and how teachers and learners code-switched in class, whether these practices shifted in any way over the three years of

TABLE I

Record of codings from observation schedules 1996, 1997, 1998

MATHEMATICS	Teacher, context	CS by Teacher (CST) 1996	1997	1998	CSLs ; use Main L 1996	1997	1998
Secondary	ST1, rural	2	2+	2+	1	2	2
	ST2, rural	2+	2	2+	3	2	2
	ST3, urban	2	2+	2+	2	2+	2+
	ST4, urban	2	2+	2+	1	3	3
Primary	PT1, rural	1	2	1	1	2	1
	PT2, rural	1 to 3	X	2	1	1	1
	PT3, rural	X	2-	2-	0	2	2
	PT4, rural	0	0	1	1	2	1
	PT5, urban	1	1	1	2	2+	2+

ST – Secondary teacher
PT – Primary teacher
Code-switching by teacher – CST
X – in that year the teacher observed was not teaching mathematics

0 = teacher only uses English in all verbal interactions

1 = teacher occasionally switches from English to main language(s) for reformulation in public and in limited individual/group interactions

2 = teacher switches from English to main language(s) for reformulation in public whole class teaching, and uses main language(s) as major language of interaction with individuals and small groups

3 = teacher switches between English and main language(s) as necessary for the flow, order and content of teaching in public whole class teaching and uses main language(s) as major language of interaction with individuals and small groups

Code-switching by learners – CSL

0 = learners only use English in all verbal interactions

1 = learners use limited English in public domain (responding to teacher questions, typically short phrases or single words, procedures require); occasionally have opportunity in individual/ group interactions to use main language(s) for questions/ exploratory talk

2 = use English in public domain (still limited to short responses), with good opportunity for exploratory talk in main language(s)

3 = switch as needed in whole class interactions; use main language for exploratory talk

4 = switch as needed in whole class interactions; use main language for exploratory talk and English for reporting on work done in public domain.

the research, and then with what possible consequences. We recorded CS by both the teacher and learners in a pre-designed observation schedule, and were able to confirm and elaborate the codings and comments on the schedule through closer study of videotape of each teacher. We have summarised the CS practices of each teacher, both primary and secondary, over the three years (1996, 1997 and 1998) of the study in Table 1. The codings used for the teachers and their learners are described below the table. In brief, '0' signals no switching, with talk by teachers and/or learners restricted to English. Increased use of learners' main language(s) then shifts from it only being used occasionally and for reformulation in the public domain (i.e. whole class teaching), and in limited learner-learner discussion, to greater use in individual and small group interaction (codings here of 1 or 2). '2+' signals that English remained dominant in the public domain, but CS was prevalent in exploratory talk in small group discussion. A coding of 3 (for the teacher) and 4 (for learners) indicates that switching takes place in support of learning and teaching. Both (and sometimes more than two) languages are used to support learner-learner exploratory talk as well as talk by learners and teachers in the public domain (whole class teaching).

As the table reveals, most of the teachers code-switched, as did their learners. Code-switching was observed during the base-line study in 1996, and thus was an already established practice of the teachers in the study when they entered the FDE programme. What can also be observed in the table is that, in general, the extent of switching increased over the three years of the study. The form that this took in most classrooms was as follows: Teachers used English predominantly in the public domain and switched to learners main language(s) for reformulation in public whole class teaching, and for interaction with individual learners or small groups. Learners also mainly used English in the public domain, limited to short phrases, single words or recall of procedures, but there were opportunities in class for exploratory talk in their main language(s). What is hidden in Table 1 is that the increased use of main languages by learners, and hence CS, was part of an organisational shift across most of the teachers to group learning. In 1997 and 1998 teachers provided learners with an opportunity to discuss their work with a partner or group, and all learner-learner interaction that we observed took place in the learners' shared main language, interspersed with mathematical English.

Of significance for this paper are the differences between the primary and secondary teachers on the one hand, and the urban and rural teachers on the other, in particular the interesting phenomenon that CS occurred least in the rural primary classrooms, those we have described as foreign language learning environments. Teachers and learners in the secondary mathematics classrooms observed made greater use of CS in comparison with the switching practices observed in the primary mathematics classrooms. And so too with teachers and learners in additional language environments in comparison with foreign language learning environments. This reflects one of the most significant things we learnt through the entire research project: how complex language issues are in rural schools where there is very limited English infrastructure in the surrounding community for teachers to build on in school. Exposure to English is via the teacher. This puts pressure on teachers to use English as much as possible. Mathematics teachers in rural schools, particularly in the senior primary levels, argued strongly against frequent code-switching in class. We also found that both rural and urban primary mathematics teachers feel the pressure to teach in English because their learners are still learning English.

That CS is an established practice in many South African mathematics classrooms, outside of current in-service initiatives, and irrespective of changing policies is not a surprise. In most of the classrooms and schools we visited, learners were clearly not sufficiently fluent in English to have all mathematics and science teaching and learning take place through English (Macdonald, 1993). In addition, that English was more 'seen' in primary foreign language learning classrooms, can be understood as teachers' seeing it as their task to model and encourage English, as the classroom is the only context in which learners have this exposure.

The increase in code-switching in most classrooms, though less so in rural primary classrooms, is further explained by the teachers themselves through their interviews. In 1997 and 1998 most of the teachers talked explicitly about how their involvement in the FDE programme gave them more confidence in using code-switching. In other words, provided them with stronger pedagogical rationales for drawing on learners' main language. An established practice was legitimated through teachers' engagement with language practices in the programme. In the words of two of the teachers, the FDE 'liberated' them with regard to code-switching.

CS nevertheless remained a difficult practice for all the teachers, both practically and ideologically. All, the mathematics teachers in the study revealed in their interviews what Adler (1998) has described as the 'dilemma of code-switching'. On the one hand as teachers they needed to switch languages in order to reformulate a question or instruction, or to re-explain a concept, and they needed to encourage their learners to use their main language in order to facilitate communication and understanding. At the same time however, it was their responsibility to induct their learners into mathematical English and hence it was important to use English in the mathematics classroom as much as possible. In the FDE study, the primary teachers experienced this dilemma more acutely than secondary teachers, and the dilemma was most acute for the rural primary mathematics teachers where the school is the only place learners can hear English being spoken. The view of the teachers was that even if learners did not always understand what is being said in English, they needed to hear English being spoken, and the teacher was thus compelled to use English as much as possible. One of these teachers (See PT1 in Table 1) who shifted from no switching in 1996 to limited switching in the public domain in 1998 revealed the dilemma and the related tension between the pedagogical and political through the contradictory views she gave in her interviews. In 1997 she said: "I use CS because learners do not understand English", and in 1998 felt that "CS does not benefit learners" who in the end have to be able to do mathematics in English.

The dilemma of code-switching, and of building mathematical English communicative competence takes on added significance in the context of curriculum reform in South Africa, and elsewhere. In addition to changing approaches to mathematics, reforms in mathematics education across the world emphasise learner centred practice, and a less interventionist and transmission role for the teacher. From our earlier discussion of Moschovich's study in the USA, where revoicing by the teacher played a significant role, we can see that contradictory discursive demands emerge in multilingual classrooms in the context of mathematics education reform. The teacher in Moschovich's study listened to and worked with learners' mathematical language productions in the public domain, revoicing these and so framing them towards appropriate mathematical discourses. On the face of it, this could be read as a strong interventionist or transmission-type practice by the teacher. The teacher, however, understood her role as including the modelling of mathematical talk for learners who were struggling simultaneously with concepts and their appropriate naming in the language of learning and teaching.

In contexts where learners have greater fluency with the LOLT there are less obvious demands on the teacher for revoicing and modelling mathematical English. Teachers' varying use of CS across contexts suggests that language in-education policy needs to engage more seriously and explicitly with what multilingual practices like code-switching can and do mean in the day to day realities of diverse classrooms contexts. In particular, in the context of mathematics education reform, policy research and development needs to embrace the specificity of demands on teachers who work in contexts with limited English language infrastructure. What, for example, does learner-centred mathematics practice mean in such contexts? Disaggregating the multilingual mathematics classroom in policy, research and practice is a significant challenge for mathematics education in South Africa, and, we believe for the wider mathematics education community.

The FDE research project, precisely because it worked across levels and regions, illuminates just how much context matters. Its very breadth nevertheless backgrounded the details of teachers and learners negotiating across languages and discourses in the mathematics classroom. For this illumination we turn to another study.

MOVING ACROSS DISCOURSES

The second study that we will discuss focuses in more detail on how teachers in urban primary multilingual mathematics classrooms use language(s) to enable learners' meaningful communication of mathematical ideas, concepts, generalisations and thought processes. What we discuss here is drawn from a wider study, still in process (Setati, 1998, 1999). We focus on one the classroom language practices of the six carefully selected grade 4 teachers in the wider study, Ntombi.

Ntombi teaches in a primary school (grades 1–8), west of Johannesburg in South Africa. She has been teaching for ten years and has a Senior Primary Teaching Diploma plus a three year university degree. Like her learners, she is a first language Tswana speaker. However, in addition to Tswana, which is one of the eleven official languages in South Africa, she can speak three other languages (English, Afrikaans, South Sotho). Her grade 4 class that was observed had 60 learners in total, 26 girls and 34 boys. They were all multilingual and could speak from two to four languages and this included English which is an additional language for all the learners in the school. Compared to other learners in the wider study, these learners were relatively fluent in English. While their level of fluency could not be compared to a main language speaker, they were able to communicate in English. The main language in the area and the school is Tswana and all the learners are fluent in it. The chosen language of learning in the school is English and its use is encouraged in the school.

We explore the ways in which Ntombi models and uses different mathematical discourses and code-switching and how these enable the development of her learners' mathematical linguistic abilities. We will argue that the language practices in Ntombi's mathematics classroom suggests a complex relationship between code-switching, the use of a range of mathematical discourses, and learners' ability to communicate mathematics. We build the argument through an analysis of the spread of qualitative data collected in the wider study by means of teacher interviews, lesson observations and learner interviews. The teacher pre-observation interview was done before the lessons were observed and focussed on the preferred language practices of the teacher. Lessons were observed for a week and the last two lessons observed were video recorded. A reflective interview with the teacher after observation of lessons focussed on the critical incidents in the lessons observed and the teacher's understanding and rationale for the language practices used during the lessons. The learner interview focussed on learners engaging in mathematical talk related to mathematics lessons observed. To analyse the lesson transcripts and learner interview, four categories are used to understand ways of talking mathematics in this classroom: informal and formal calculational discourse and informal and formal conceptual discourse.

The lessons taught

Five consecutive lessons were observed in the same grade 4 class and they all focussed on multiplication. To introduce the first lesson Ntombi started by writing the word 'multiplication' on the board and talked with the learners about what it means both in Tswana and in English. She proceeded to give them an example on the board:

14	This was elaborated procedurally; 6 times 4 is
× 16	24, write 4 carry 2. 6 times 1 is 6 plus 2 is 8.
84	1 times 4 is 4, 1 times 1 is 1. 4 plus zero is 4,
+14	8 plus 4 is 12, write 2 carry 1 and 1 plus 1 is
224	2. Therefore the answer is 224.

This was followed by group exercises and then class-work which were both similar to the example. During group work there was a lot of interaction, mainly in Tswana, between learners. During teaching, Ntombi communicated with learners in both English and Tswana and engaged them in mainly formal calculational discourses. These kinds of discourses were also observed among learners during group work.

Lesson 2 started with checking and marking of homework. Volunteers from different groups were called to the board to write their solutions. If the answer on the board was incorrect another volunteer was requested. Ntombi identified those who had problems with the homework and did more examples with them, emphasising the procedures to follow, while the rest of the class continued with more multiplication problems. After working with the selected group she gave them an exercise to do as homework. Both Ntombi and her learners used English and Tswana interchangeably. In other words, there was frequent code-switching. Formal calculational discourse was dominant during this lesson. The lesson ended with the whole class singing a song while they put away their mathematics books.

As in lesson 2, lesson 3 started with checking and marking of homework. She then worked with one group (whom she described as a 'good group') on multiplication of three digit numbers by two digit numbers while the rest of the class was busy with corrections. Code-switching and formal calculational discourses were also dominant during this lesson.

After checking and marking homework in different groups during lesson 4, Ntombi worked with the same ('good') group on a word sum while the rest of the class was very noisy and not involved. The 'word sum' she did with the group was: "In Thusong primary school, there are 10 classes and in each class there are 19 learners. How many learners are there in Thusong?" After doing this example she started a song to regain learners' attention. At the end of the song she wrote two different exercises on the board: one for the 'good group' and the other for everyone else. For the 'good group': "In KTS there are 15 classes. In every class there are 13 learners. How many learners are there in KTS school?", for the rest of the class: 301 × 15, 408 × 19, 485 × 15. During this lesson (as evidence following will confirm), the discourses in use became more informal and conceptual. Code-switching continued to be a dominant practice.

In lesson 5, after checking and marking the home work, she continued to work with the 'good group' on another word sum example: "In the SPCA (*Society for the Prevention of Cruelty to Animals*) are 12 cages. In each cage are 12 dogs. How many dogs are there altogether?" The rest of the class was working on lesson 4's word sum. In handling the word sum with the 'good group', the teacher started by asking learners to read and then focused on the new words like 'SPCA', 'cage' asking them what they mean. Most of the learners' explanation of these words were in Tswana. This was followed by a discussion on what they were required to find in the word sum and how the solution can be found. After finding the solution she wrote two different exercises on the board for the learners to do as a class test. During this lesson the teacher engaged learners in both formal and informal as well as calculational and conceptual discourses.

A description of talk in and across lessons

During teaching, Ntombi focussed mainly on formal mathematics language. Her classroom mathematical discourse moved across calculational and conceptual discourses. She taught procedures explicitly. Throughout lessons 1, 2, 3 she led the learners in calculational processes used to solve problems. Her focus seemed to be on getting the learners to master the procedure and not on the reasons for using the procedure or on why the procedure works. Her talk was in terms of procedures where numbers are manipulated as objects that can be 'carried'. For instance, "We carry down

1 and say 9 plus 3 is 12". What is interesting is that the teacher is not the only one who 'owned' this kind of talk. She modelled the talk and then gave learners an opportunity to practise it. This was evident during the lessons and in the learner interviews where learners used the language of the teacher in most of their discussions. As is inevitable in reporting qualitative research, it is not possible to display full interactional transcripts here. The excerpts that follow are selected to serve as examples and illustrations of the wider data pool.

In the extract below the learner is working out the solution for 444 × 19 as part of whole class interaction.

P: Let us say 9 times 4 is 36.We write 6 and carry 3 then again we say 9 times 4. 36 + 3 is 39 we write 9 and carry 3.We say 9 times 4 again is 36 plus 3, 39 and cover the units. We say 1 times 4 is 4. And again 1 times 4 is 4.We say again 1 times 4 is 4 and then we underline and then 6 plus 0 is 6. 9 plus 4 is 13 carry 1. 9 plus 4 is 13 plus 1 is 14 carry 1. 3 plus 1 plus 4 is 8.

(Lesson 4)

In the above extract, the learner is imitating the 'teacher's language' of mathematics where numbers are referred to as objects that can be 'covered' and 'carried'. This kind of talk can be described as calculational discourse because the learner is explaining the procedure she will follow to solve the problem. She, however, is not explaining the reasons why she is using the procedure or why the procedure works. It is also important to note that this calculational discourse occurs in English. The above extract is typical of how calculational discourse occurred during Ntombi's lessons.

It can be argued that this kind of talk can and does occur in many mathematics classes. The difference in Ntombi's multilingual class is that she also engaged her learners in conceptual discourse and this switch in discourse brought with it, a switch in language (from English to Tswana). This was evident in Lesson 5 when Ntombi introduced the word problem below:

In the SPCA are 12 cages, in each cage are 12 dogs. How many dogs are there altogether?

Ntombi wrote the problem on the board and asked the learners to read it. She then dealt with two words in the problem that were unfamiliar to the learners: 'SPCA' and 'cage'. The extract below is typical of how Ntombi dealt with the unfamiliar words.

T: Eh, can you all read here?

P: In the SPCA there are 12 cages, in each cage are 12 dogs. How many dogs are there altogether?

T: Now, first of all, what is this SPCA?
P: When your dog is ill . . ., when your dog is ill . . . Can I say it in Tswana?
T: Yes, sure.
P: Fa ntja ya gago e lwala go na le batho ba tlang ba tla go tsaya ntja ya gago a ba e isa ko spetlele fa ba bona e le botoka ba e busa. [If your dog is ill, there are people who will come and take it to the hospital and they bring it back when it is well.]

(Lesson 5)

In the above extract, Ntombi is dealing with the word SPCA, which could be new to most learners. While SPCA is an abbreviation for an English phrase 'Society for Prevention of Cruelty to Animals', its meaning is discussed in Tswana. This extract illustrates, firstly, that Ntombi uses this opportunity to ensure that learners understand the meaning of new words like 'SPCA', and secondly, that learners' engagement in this informal conceptual discourse took place in Tswana. This switch into Tswana enabled active interaction in informal conceptual discourse with the teacher.

After ensuring word meanings, Ntombi asked the learners to interpret each of the sentences in the word sum. In interpreting the sentence "In each cage are 12 dogs" Ntombi made drawings of the cages and of the dogs inside the cages and then moved on to what the question requires learners to do.

T: Ee ke raa gore tla re baleng potso e. [Let's read the question.]
Ps: How many dogs are there altogether?
T: Go raa goreng? [What does it mean?] Ke batla go tlhaloganya seo pele. [I want to understand that first] Morero ke eo potso e re botsa gore dintja tso tsotlhe tse di mo dicaging di di kae. [Morero, there's a question, it says, how many dogs are there altogether in the cages.] Dintja tso tsotlhe di di kae? [How many dogs are there altogether?] Jaanong ke batla go itse gore karabo re a go e bona jang. [I would like to know how are we going to find the answer.]
P: We are going to write tens, hundreds, thousands and units. (Puts chart on the board.) . . . and we must underline, when we are through we say 12 times 12, we underline again when we are through we put the button here and we say 2 × 2. . . (Learner goes on with the procedure in English until he gets the answer)
P: The answer is 144.
T: Go raa gore re na le dintja tse kae? [It means how many dogs do we have?]
P: 144.

(Lesson 5)

Ntombi begins here by rephrasing the question for the learners in Tswana. What is interesting is that in order to respond to the teacher's question:

"How are we going to find the answer?" the learners move out of the informal conceptual (contextual) discourse in which they have been interacting with the teacher, and into the formal calculational discourse which they have learned. This switch is not only between informal conceptual discourse and formal calculational discourse. It is also between everyday informal language and formal mathematical language as well as between Tswana and English. This is not surprising. Informal language develops from everyday experience in learners' main language (Tswana), usually outside the formal school setting. In contrast, formal mathematical language develops from within formal settings like school where the language of learning and teaching is English. According to Mphunyane (1996: 19), "linking informal and formal mathematical languages forms one dimension for paving a way towards development of 'true' mathematical concepts, the merging of spontaneous and scientific concepts; hence mathematical knowledge".

What the above extract shows is that these learners are aware of the dominant culture of mathematics classrooms in which formal written mathematical language is valued and therefore when required to give an answer they draw on their knowledge of formal procedures. Another interesting observation is that the formal calculational discourse occurs in English. This is possibly due to the practice in this classroom where this discourse is acquired in English.

In the next extract Ntobmi tries to engage the learners more in formal conceptual discourse.

T: 144. Mara jaanong go tlile jang gore re tshwanetse gore re di timese ko gonne nna nka nne ka nagana gore mare why re sa re 12 plus 12? [But now, how did you know that you are supposed to multiply, why are we not saying 12 plus 12?]

Kenosi: Because re batla di answer tsa rona di be right. [Because we want our answers to be correct]

T: Oh, Kenosi o arabile are o batla go bona a tshwara dipalo tsa gage right ke moo a reng 12×12. [Kenosi has responded, he wants his answers to be correct.] O mongwe a ka reng? [What do the others say?]A ka re tlhalosetsa jang?[How else can you explain this?] (A few pupils raise their hands and she points at one.)

T: O batla go leka? [Do you want to try?] Emella re utlwe, Ntsiki? [Stand up and try, Ntsiki]

Ntsiki: Bare ko SPCA go na le di 12 cages ene gape go na le dintja tse 12 bjanong ge re di bala dintja tse di di kae? [They say at the SPCA there are 12 cages and 12 dogs in each cage, so when you count the dogs in each cage what will you get?]

(Lesson 5)

It is interesting that when Ntombi asks the learners why they multiplied, the first reason they give is that they want their answers to be correct. This is typical of most mathematics classrooms where it is important to know what the correct answer is and not why the answer is correct. On asking for an alternative explanation of how they decided to multiply 12 by 12, Ntsiki used the teacher's drawing to explain why 144 is an appropriate answer, and did so using formal conceptual discourse in Tswana.

Reflecting back on all five lessons, four of which were focussed mainly on calculations, Ntombi communicated to learners what is valuable mathematics language. It is thus not surprising that when the learners were engaged in informal conceptual discourse in Tswana they quickly shifted back to the formal calculational discourse in English. Nevertheless, throughout the week, despite an emphasis on calculations, the extracts above show how at different moments, Ntombi's learners were exposed to and engaged in all four kinds of discourses.

During the learners' interview they could draw on all kinds of discourses. Mathematically, Ntombi's learners were able to engage in both calculational and conceptual discourses. They could carry out their procedures with ease and whenever they were required to give reasons for some of the steps in their procedures they managed well. It is feasible to argue here that Ntombi's ways of talking enabled learners both mathematically and linguistically. The extract below is a typical example of how learners were able to use both conceptual and calculational discourses in English. (I = interviewer; L = Learner)

L: There are five rows of cars with three cars in each row. How many cars are there altogether? Okay, we must draw a road and a car.
I: How many?
L: we must draw five rows and three cars in each.
L: But I don't know how to draw a car,. . . nna ke tla drowa tsela [I will draw a road] . . .then after I do like this. Then after I draw another one; it's one row here. And I draw again a row.
I: Okay.
L: Then after I draw again a car; and that car is moving.
I: Okay.
L: Then after. . . it has three . . . then after I write a road because; I am not going to draw a car again because they say there are five rows of cars with . . . there are five rows ofcars with three cars in each row. Okay I understand now! They said here it's a. . .it's three cars and here it's three cars and here it's three cars and here it's three cars, and again I draw again a car here. And in each. . . Then after I draw a last row, I draw a car again.Then after we have. . .

I: So how many cars do you have altogether?
L: Altogether there are fifteen.

(Learner interviews)

Our analysis of Ntombi's language practices suggests an important relationship between code-switching, the kinds of mathematical discourses used and whether these enable or constrain learner access to communicating mathematics. Ntombi used a range of discourses in her teaching and these were reflected in the learners' communication of mathematics. The movement between discourses was facilitated by the use of the learners' main language (Tswana). This is particularly important because while Ntombi's learners' are relatively fluent in English, it is not their main language and as the data shows some of the learners could not engage in calculational and conceptual discourses without using their main language, Tswana. It is therefore possible that if Ntombi did not allow them to use Tswana, the discourses could have remained formal and procedural, or in Arthur's (1994) terms, restricted to a 'final draft' format.

In Bassey's (1999: 51) terms, we are drawing a 'fuzzy generalisation' from this case study. *In urban multilingual primary classrooms like Ntombi's, the use of code-switching is likely to enable shifts between informal, formal, calculational and conceptual discourses and this in turn is likely to enable learners' communication of mathematics.* In multilingual primary mathematics classrooms, negotiating across languages is intertwined with negotiating across discourses. The suggested relationship between code-switching, mathematical discourses and whether and how they enable learners to communicate mathematics is indeed a fruitful area for further research in mathematics education.

CONCLUSION

Our major purpose in this paper has been to extend debate and discussion on code-switching as a language practice in primary mathematics classrooms. We began with a discussion of research on bilingual educational in general, and in mathematics teaching and learning in particular. We pointed to research that demonstrated serious teaching and learning limitations when learners' main language(s) were not drawn on for classroom communication. We argued that code-switching should be expected as a particular phenomenon in bi/multilingual classrooms, and that such practices are inevitably complex. In order to meet our major purpose, we drew on two studies in the South African context, each of which highlights some of the complexity of code-switching practices in multilingual primary mathematics classroom.

The overarching conclusion that we have drawn is that while at a general political and pedagogical level it makes sense for teachers to encourage and use learners' main language(s) as a learning and teaching resource, this is no straightforward matter. Firstly, different LOLT infrastructures in and around the classroom make different demands on primary mathematics teachers. The need for practices like revoicing and a strong role for the teacher in displaying and using mathematical English is greatest in rural classrooms in South Africa, classrooms which we have described as foreign language learning environments. The different English language infrastructures and levels at which teachers work are likely, therefore, to shape teachers' practices and INSET possibilities and constraints. This illumination is critical in a mathematics education reform environment where 'teacher talk' is discouraged. The implication for curriculum, language-in-education policy and further research is the need to dis-aggregate schools and mathematics classrooms along these different axes. Further research, curriculum and development programmes need to be tailored according to whether they are within English Foreign Language or English Additional (Second) Language environments and whether they are within primary or secondary classrooms. Our view is that it is feasible that without such specific contextual attentions, we might, however unintentionally, exacerbate educational inequalities.

Secondly we have shown how the movement between languages in the primary mathematics classroom is bound up with movement across mathematical discourses – where the one practice enables the other. We framed our discussion here with an elaboration of the movement required in a mathematics classroom from informal talk in the main language to formal talk and writing in English. We went further to highlight distinct discourses within formal mathematics. Through our interpretation of a particular teacher who used code-switching as a teaching and learning resource in her classroom, we demonstrated a relationship between code-switching on the one hand, and the teacher and her learners' movement across different mathematical discourses on the other.

In summary, our research has illuminated some of the complexity of code-switching practices in multilingual primary mathematics classrooms. Perhaps more significantly, this research points to the need for further research, research that investigates CS in diverse contexts on the one hand, and in relation to the range of mathematical discourses in school on the other. In the South African context in particular, code-switching *is* a resource in the multilingual primary mathematics classroom. Attention to code-switching and its use in multilingual mathematics classrooms is an important part of a process of legitimising what teachers actually do (i.e. harness learners' main language as a resource for learning) in a context where pressure to access and acquire English is enormous. However, further research is needed to influence language-in-education policy such that complexity in diversity is practically and formally recognised.

NOTES

1. We use 'multilingual' as an attribute of the learner or teacher, and as a descriptor of classes in South Africa. A multilingual learner is one who speaks more than two languages. A multilingual class is one in which there is a teacher and many languages to the class, but the teacher and learners themselves are not necessarily multilingual. Similarly with 'bilingual'.
2. Formal mathematics, mathematical discourses and the mathematics register have overlapping meanings but they are not one and the same. In this paper we use mathematical discourses to mean ways of talking (about) mathematics, listening to mathematics, acting in a mathematics class or community, interacting mathematically, believing, valuing and using mathematics and /or the mathematics register (adapted from Gee's definition of Discourse, 1996). Mathematical discourses develop out of both formal and informal communication of mathematical ideas, so there may be a range of discourses in one community. We use mathematics register to refer to a formally developed set of meanings that belong to the language of mathematics and that a language must express if it is being used for mathematical purposes (Halliday, 1978). So, while a formal mathematics register may not exist in a particular language, a range of mathematical discourses will exist because of the need to communicate mathematical ideas in different languages.
3. These are two of the nine provinces in South Africa. Gauteng is the industrial hub of the country, largely urban and one of the richer provinces. In contrast, the Northern Province is dominantly rural and poor. Conditions in schools across the two provinces vary enormously.
4. As is inferred, socio-economic conditions are the most significant factor in the urban/rural divide in SA education. Rural schools are largely impoverished contexts, with many having been denied basic resources like electricity and water (Bot, 1997). Our focus on the linguistic context here is not to deny these additional contextual issues but to highlight the particular language and learning challenges produced across different contexts.

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