Researching Mathematics Education and Language in Multilingual South Africa

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This paper explores policy, practice, and research issues that relate to the teaching and learning of mathematics in multilingual classrooms of South Africa. The paper begins with a brief history of language-in-education policy in South Africa to show how such policy is driven by political as well as educational interests. Thus the paper sets up what will be the main argument: Language-use in a multilingual educational context like South Africa is as much, if not more, a function of politics[1] as it is of communication and thinking. The relationship between language and mathematical learning is considered from a range of perspectives, drawing from a range of literature in the field not confined to South Africa. I will focus specifically on code-switching in multilingual mathematics classrooms, as it is this practice that has been the object of recent research in South Africa. This review of theoretical and empirical work will point to the significance of language as power in mathematics education settings and thus demonstrate the need for researching the relationship between language and the teaching and learning of mathematics in South African classrooms from a political perspective.

The history of language-in-education policy in South Africa

The history of language-in-education policy in South Africa is controversial, particularly regarding the language of learning and teaching (LoLT) in African[2] schools. This history has been interwoven with the politics of domination and separation, resistance and affirmation (African National Congress [ANC], 1994).

The LoLT history in African education can be traced back to the policies of missionary education during the 19th century. In mission schools English featured strongly as a LoLT as well as a school subject. This English as LoLT policy in missionary schools was continued by government-aided African education following the Union of South Africa in 1910 (Beukes, 1992). The importance of learning in the main language gradually came to be recognized in Natal and also in the Cape Province (Hartshorne, 1987). Between 1910 and 1948 the language in education policy was flexible, and different provinces made their own decisions about languages of learning. For instance, in Natal the LoLT in African schools was Zulu for the first six years of schooling (i.e., up to and including Grade 6) until 1948 (Hartshorne).

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Language in education during Apartheid

When the Nationalist government came into power in 1948, African schools were removed from provincial administrations and placed under the National Department of Bantu Education. In 1949 the Nationalist government appointed a Commission on National Education, chaired by Dr. Eiselen. At the end of two years, the commission recommended a rigid *mother tongue instruction* policy in the name of Christian National Education (Hartshorne, 1987). The commission recommended that

> … all education should be through the medium of the mother tongue for the first four years, and that this principle should be progressively extended year by year to all eight years of primary schooling (p. 68).

However, the government did not follow the Eiselen report closely, largely because of its concern with protecting and expanding the influence of the Afrikaans language in the system (Hartshorne).

In 1953 the government passed the Bantu Education Act which stipulated that mother tongue instruction be phased in across all primary school Grades in African primary schools, with English and Afrikaans as compulsory subjects from the first year of schooling. At the time, English and Afrikaans were the only two official languages. The latter language had developed out of Dutch settlement. In addition, both English and Afrikaans were also to be used as languages of learning and teaching on a 50/50 basis when transfer from main language[3] learning took place in the first year of secondary school (Hartshorne, 1987). The educational interests of the pupils became subordinate to ideological and political factors. The government's greatest concern at the time was that the constitution of South Africa required equality in treatment of the two official languages. These policies were centered on fears that the Afrikaner language, culture, and tradition

might be overwhelmed by the older, more internationally established English language, culture and tradition (Reagan & Ntshoe, 1992).

Alongside these policies for African learners, white, so-called "coloured", and Indian schools were also segregated along apartheid racial lines but came under different legislation. Learners in these schools were required to take both English and Afrikaans throughout the 12 years of school, one at a first language level, and the other at either first or second language level. Depending on department and location, the LoLT in these schools was either English or Afrikaans, or in some cases dual medium. As English and Afrikaans were the main languages of white, coloured, and Indian learners, these learners were able to learn through the medium of their main language in both primary and secondary schools.

Hartshorne (1987) has argued that the language policy in African education in South Africa since the 1948 election (and particularly since the Bantu Education Act) has centered on two major issues: mother tongue instruction and the establishment of the primacy of Afrikaans as the preferred LoLT in secondary school. The majority of the African people rejected both these issues. Though not unmindful or ashamed of African traditions per se, mainstream African nationalists have generally viewed cultural assimilation as a means by which Africans could be released from a subordinate position in a common, unified society (Reagan & Ntshoe, 1992). Therefore, they fought against the use of African languages in schools, since their use was seen as a device to ensure that Africans remain "hewers of wood and drawers of water" (p. 249).

The LoLT issue became a dominating factor in opposing the system of Bantu Education during the apartheid era. African opinion never became reconciled to the extension of first language learning beyond Grade 4 nor the dual medium policy (of English and Afrikaans) in secondary school (Hartshorne, 1987). Many analysts trace the 1976 uprising, which began in Soweto and spread all over the country, to rather belated attempts by the Nationalist government to enforce the controversial and highly contested 50/50 language policy for African learners that was first promulgated in 1953. This policy prescribed that all African children at secondary school should learn 50% of their subjects in Afrikaans and the other 50% in English. African teachers were given five years to become competent in Afrikaans.

In 1979, in the wake of the 1976 revolt, the government introduced a new language policy. This new policy emphasized initial main language learning with an eventual shift in the LoLT to English or Afrikaans. As a general rule, the African child began his or her schooling in the main language, which remained the LoLT through the fourth year of schooling (Grade 4). During these first four years both English and Afrikaans were studied as subjects. Beginning in the fifth year of schooling (Grade 5), there was a shift in the LoLT to either English or Afrikaans, the official languages of the country.

In 1990 the Nationalist government passed an amendment to the 1979 Act giving parents the right to choose whether their child would be immediately exposed to a second language (e.g., English) as the LoLT (from Grade 1), or would experience a more gradual transfer. While there is no systematic research evidence, it is widely held that many schools with an African student body adopted English as the LoLT from Grade 1 (Taylor & Vinjevold, 1999).

The unbanning of liberation movements and the release of Nelson Mandela in February of 1990 signalled the beginning of a new era for South Africa. The ANC was voted into power in 1994 and multiple policy initiatives began across all social services. In terms of language policy, a process to fully recognize the rich multilingual nature of South Africa was initiated. The constitution adopted in 1996 for a post-apartheid South Africa recognizes 11 official languages. For the first time nine African languages—Sesotho, Sepedi, Setswana, Tshivenda, Xitsonga, IsiNdebele, IsiXhosa, IsiSwati and IsiZulu—received official status, in addition to English and Afrikaans. In 1997 a new language-in-education policy that recognizes 11 official languages was introduced.

Language in education in the new South Africa

According to this policy, not only can South African schools and learners now choose their LoLT, but there is a policy environment supportive of the use of languages other than one favored LoLT in school, and so too of language practices like code-switching. While this new language-in-education policy is widely acknowledged as "good", it is already meeting significant on-the-ground constraints. Recent research suggests that most schools are not opting to use learners' main languages as LoLTs in both policy and practice (Taylor & Vinjevold, 1999). This situation is not unexpected; as described earlier, main language as LoLT policy or mother tongue instruction has a bad image among speakers of African languages. It is associated with apartheid and hence inferior education.

While the new language policy in South Africa is intended to address the overvaluing of English and Afrikaans and the undervaluing of African languages, in practice English continues to dominate. Even though English is a main language of a minority, it is both the

language of power and the language of educational and socio-economic advancement, thus it is a dominant symbolic resource in the linguistic market (Bourdieu, 1991) in South Africa. The linguistic market is embodied by and enacted in the many key situations (e.g., educational settings, job situations) in which symbolic resources, like certain types of linguistic skills, are demanded of social actors if they want to gain access to valuable social, educational, and eventually material resources (Bourdieu).

Various institutional arrangements and government policies continue to produce the dominance of English in the linguistic market. First, the LoLT in higher education institutions is either English or Afrikaans, and it seems that this policy will continue for many more years since it has not yet been challenged in higher education circles. Second, there is an English/Afrikaans-language pre-requisite for anyone aspiring to become a professional in South Africa. Students need to pass a school-leaving examination in English as a first or second language, in addition to mathematics, to enter and succeed in the English-medium training programs in professional fields such as medicine and engineering and in order to earn qualifications to enter high-income professions. "The symbolic market is therefore not a metaphor but one with transactions that have material, socio-economic consequences for individuals" (Lin, 1996, p. 53).

Third, there are still policies upholding English as an official, legal, and government language. The nine African languages spoken by the majority of South Africans are still secondary to English in reality; for example, most of the policy documents are written in English only. Fourth, there is imposition of an English-language requirement for individuals aspiring to join the civil service. For instance, ability to communicate in English is one of the requirements for anyone willing to train for police or military service. The fact remains that English is the most important criterion for selection for high-ranking officials; knowledge of an African language is seen as an additional asset but not an essential one.

With these institutions and policies well-entrenched in the various administrative, educational, and professional arenas of South Africa, a symbolic market has been formed where English constitutes the dominant, if not exclusive, symbolic resource. It is a prerequisite for individuals aspiring to gain a share of the socio-economic, material resources enjoyed by an elite group.

Recognizing the historically diminished use and status of the nine African languages of the people of South Africa, in December 1995 the Minister of Arts, Culture, Science and Technology announced the establishment of a Language Plan Task Group (LANGTAG). Its role was to identify South Africa's language-related needs and priorities. Since then, LANGTAG has articulated a multilingual policy for South Africa. It proposed a widespread use of the nine African languages in all spheres. This proposal was challenged by some members of the division of Applied English Language Studies at the University of the Witwatersrand, who believe that the widespread use of the nine African languages will not necessarily alter the status and power of English (Granville, et al., 1998). They proposed that all learners be guaranteed access to the language of power (English), while at the same time ensuring redress for African languages. They maintain that this redress will enable teachers to teach English as a subject without guilt and to help learners understand that all languages are valuable and are a national treasure (Granville, et al.). The issue of the dominance of English in South Africa is not easy to resolve. As Sachs, a constitutional court judge, pointed out, in South Africa "all language rights are rights against English" (1994, p. 1).

The above discussion highlights the link between language and politics in South Africa. It is clear that in South Africa, change in language-in-education policy has been linked to change in political power. Thus if "mathematics education begins in language, [it] advances and stumbles because of language" (Durkin, 1991), then the politics of changing language policies must impact on mathematical teaching and learning practices particularly in multilingual classrooms. Just like the language-in-education policy, changes in the school curriculum in South Africa have been preceded by changes in political power.

The school mathematics curriculum context of South Africa

In 1995 the Minister of Education announced the introduction of the new curriculum. This curriculum was intended "to overturn the legacy of apartheid and catapult South Africa into the 21st century" (Chisholm, et al., 2000, p. 8). It would bring together education and training, content and skills, values and knowledge. In March 1997 this curriculum was launched and became known as *Curriculum 2005* (National Department of Education [NDE], 1997).

According to *Curriculum 2005* a minimum of two languages should be offered; however, there is no prescription as to what these languages should be. Multilingualism is recognized as a valuable resource. According to the official document,

> The advancement of multilingualism as a major resource affords learners the opportunity to develop and value: their home languages, cultures and literacies; other languages, cultures and literacies in

> our multilingual country and in international contexts; and a shared understanding of a common South Africa (Department of Education [DoE], 1997).

A focus on an integrated and non-disciplinary division of knowledge in *Curriculum 2005* led to an introduction of eight learning areas that replaced school subjects. The understanding here was that learning areas would promote strong integration of what is learned both academically and in everyday life (Chisholm, et al., 2000). The official description of the mathematics learning area is that

> Mathematics is the construction of knowledge that deals with qualitative and quantitative relationships of space and time. It is a human activity that deals with patterns, problem solving, logical thinking etc., in an attempt to understand the world and make use of that understanding. This understanding is expressed, developed and contested through language, symbols and social interaction (DoE, 1997).

The above description emphasizes the role that language plays in the expression, development, and contestation of mathematics. This view highlights language as a tool for communication, thinking and politics in mathematics. The role of language in mathematics is also highlighted in the specific outcomes for mathematics. Outcome 9 states that learners should be able to "use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes." In the elaboration of this outcome, the policy documents states that

> Mathematics is a language that uses notations, symbols, terminology, conventions, models and expressions to process and communicate information. The branch of mathematics where this language is mostly used is algebra and learners should be developed in the use of this language.

Curriculum 2005 was reviewed during the year 2000. As a result of the review, a task team was appointed to develop a national curriculum statement for mathematics. Language and communication of mathematics are again emphasized in the national curriculum statement. Learning outcome 2 that focuses on patterns, functions and algebra states, "the learner should be able to recognise, describe and represent patterns and relationships, and solves problems using algebraic language and skills" (Chisholm, et al., 2000).

As the above discussion shows, there is an explicit focus on multilingualism and the communication of mathematics in the present mathematics school curriculum. This focus raises questions about the language used for communication and how mathematics teachers find a balance between making language choices in their multilingual classrooms, advancing multilingualism, and initiating learners into ways of communicating mathematics.

In the remainder of the paper I explore the complex relationship between language and mathematics, drawing on research in South Africa and elsewhere. As stated above, I develop an argument for the centrality of the political for both research and practice in language and mathematics education. Without such a focus we will fail to understand and so work with the demands that teachers face.

The relationship between language and mathematics

In his seminal work, Pimm (1987) explored some of the connections between language and mathematics He argues that one way of describing the relationship between mathematics and language is in terms of the linguistic notion of register.

> The mathematics register is a set of meanings that belong to the language of mathematics (the mathematical use of natural language) and that a language must express if it is used for mathematical purposes….We should not think of a mathematical register as constituting solely of terminology, or of the development of a register as simply a process of adding new words (p. 76).

Part of learning mathematics is acquiring control over the mathematics register—learning to speak, read, and write like a mathematician. The mathematics register includes words; phrases; symbols; abbreviations; and ways of speaking, reading, writing and arguing that are specific to mathematics. Since mathematics is not a language like French or Xhosa, speaking or writing it requires the use of an ordinary language, the language in which mathematics is taught and learned. As discussed earlier, a majority of learners in South Africa learn mathematics in a language that is not their main language. Thus communicating mathematically in multilingual classrooms in South Africa means managing the interaction between the following:

- ordinary English and mathematical English.
- formal and informal mathematics language.
- procedural and conceptual discourses.
- learners' main language and the LoLT.

The interaction between ordinary English (OE) and mathematical English (ME)

As Pimm (1987) argues, speaking like a mathematician does not just involve the use of technical terms, but also phrases and characteristic modes of arguing that are consistent with the

mathematics register. Mathematical speech and writing have a variety of language types that learners need to understand in order to participate appropriately in any mathematical conversation. These types are ordinary and mathematical English, or logical language and meta-language (Pimm; Rowland, 1995). Mathematical English can be described as the English mathematics register, in the same way that we can have mathematical French, or mathematical Swahili. One of the difficulties of learning to use mathematical English is that in its spoken (sometimes also in its written) form it is blended with ordinary English (natural language), and the distinction between the two languages is often blurred. Mathematical English is embedded in the language of predicate logic, which includes items such as "and", "or", "if…then", "some", "any", and so on (Rowland). These words from the language of predicate logic can be confusing when used in mathematical conversations (spoken or written) because they can appear to belong to ordinary English when in fact they have been redefined for logical reasons. Pimm uses the following example to highlight one of the difficulties with the word "any". Consider the following two questions:

a) Is there any even number which is prime?
a) Is any even number prime?

According to Pimm (1987), question a) is clear and the response to it is "yes, 2 is an even number and it is also prime". Question b), however, is not clear and can be interpreted in two conflicting ways:

- Is any (i.e., one specific) even number prime? Answer: Yes, 2 is an even number and it is also prime.
- Is any (i.e., every) even number prime? Answer: No, almost all are not prime.

The source of the difficulty in the above example is the mathematical meaning of the word "any". While the word "any" is used widely in mathematics at all levels, it is ambiguous. It may be used to mean *every* or *some*. For example the question "is any rectangle a rhombus?" can legitimately be answered both "yes, a square is" and "no, unless it happens to be a square". According to Pimm (1987), mathematicians tend to use "any" to mean "every", and on occasion, their meaning conflicts with ordinary usage. However, it is clear from the above examples that the word "any" is not used consistently in mathematical English. The same can be said of other logical connectors such as "if…then". Mathematics words can also mean different things depending on whether they are used informally or in a formal mathematical conversation.

Formal and informal mathematics language

In most mathematics classrooms both formal and informal language is used, in either written or spoken form. Informal language is the kind that learners use in their everyday life to express their mathematical understanding. For example, in their everyday life, learners may refer to a "half" as any fraction of a whole and hence can talk about dividing a whole into "three halves". Formal mathematical language refers to the standard use of terminology that is usually developed within formal settings like schools. Considering the above example of a "half", in formal mathematics language it is inappropriate to talk about a whole being divided into three halves. If any whole is divided into three equal parts, the result is"thirds".

The valued goal in school mathematics classrooms is formal written mathematical language (Setati & Adler, 2001). Pimm (1991) suggests two possible routes to facilitate movement from informal spoken language to formal written mathematical language. The first is to encourage learners to write down their informal utterances and then 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 writing it down.

I have previously argued that in multilingual mathematics classrooms where learners learn mathematics in an additional language, the movement from informal spoken language to formal written language is complicated by the fact that the learners' informal spoken language is typically not the LoLT (Setati & Adler, 2001; Setati, 2002). Figure 1 shows that the movement from informal spoken to formal written mathematics in multilingual classrooms occurs 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 formalizing and translating the written mathematics into the LoLT. Another possibility is to work first on translating the informal spoken mathematical language into spoken English and then on formalizing and writing the mathematics. Of course there are other possible routes that can be followed.

As can be seen in Figure 1, while formal written mathematics in the learners' main language(s) is a possibility, there are no routes to or from it. There are a variety of reasons why most mathematics teachers in multilingual classrooms in South Africa would not work on formalising spoken and written mathematics in the main language:

- The mathematics register is not well developed in most of the African languages.
- Due to the dominance of English this work would generally be seen or interpreted as a waste of time.

Procedural and Conceptual Discourses

In addition to both spoken and written modes of formal and informal mathematics, mathematics in school is carried out by distinctive mathematics discourses. For example, Cobb (Sfard, Nesher, Streefland, Cobb, & Mason, 1998) 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 the reasons for calculating in particular ways also become explicit topics of conversations (Sfard, et al.). Previously I have referred to procedural and conceptual discourses where procedural discourse focuses on the procedural steps to be taken to solve the problem. I have argued for the use of the term procedural discourse rather than Cobb's calculational discourse because "procedural" is self-explanatory (Setati, 2002). To give an example, in the problem 28 + 18, learners can enter into discussions focusing on the procedure (or calculational processes) to follow without focusing on why the procedure works (e.g., why they do not write 16 under the units). Another possibility is that learners can solve this problem by engaging in discussions about the problem and also about why a particular procedure works (conceptual discourse).

In conceptual discourse, the learners articulate, share, discuss, reflect upon, and refine their understanding of the mathematics that is the focus of the interaction or discussion. It is the responsibility of the teacher to arrange classroom situations in which these kinds of interactions are possible—classroom situations where conceptual discourse is not just encouraged but is also valued. The teacher, as a "discourse guide" (Mercer, 1995), conveniently acts to a considerable extent as an intermediary and mediator between the learners and mathematics, in part determining the patterns of communication in the classroom, but also serving as a role model of a "native speaker" of mathematics (Pimm, 1987). As a consequence, from their interactions with the teacher, students learn the range of accepted ways in which mathematics is to be communicated and discussed. The teacher models the accepted ways of acting-interacting-thinking-valuing-speaking-reading-writing mathematically.

Teachers can encourage conceptual discourse by allowing learners to speak informally about mathematics—exploring, explaining, and arguing their interpretations and ideas. The challenge here is for the teacher to know when and how to lead learners from their informal talk to formal spoken mathematics. If the teacher intervenes prematurely, she could unintentionally discourage learners from expressing and exploring their conceptions regarding the mathematics that is being discussed. This kind of exploratory talk is important for learners to develop

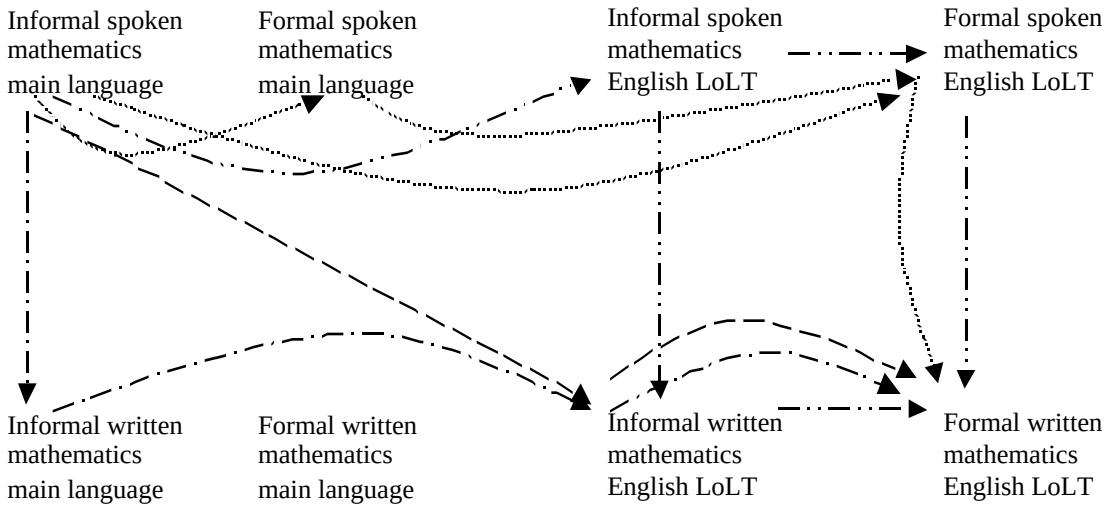

Figure 1. Alternative routes from informal spoken (in main language) to formal written (in English) mathematics language.

ideas and concepts in a comfortable environment. It is also important for enabling teachers to listen to learners' ideas and conceptions so that these can be worked with and built upon (Setati, Adler, Reed, & Bapoo, 2002). It is in this environment of informal exploratory talk that learners begin to acquire conceptual discourse. Therefore the teacher is faced with the challenge of keeping a balance between informal and formal spoken language and of making sure that the learners explore their ideas sufficiently in informal ways in order to acquire fluency in formal conceptual discourse. Adler refers to this challenge as the *dilemma of mediation*:

> The dilemma of mediation involves the tension between validating diverse learner meanings and at the same time intervening so as to work with the learners to develop their mathematical communicative competence (Adler, 2001, p. 3).

This dilemma of mediation highlights a key challenge in the context of *Curriculum 2005*, where learner participation is valued and teachers strive for inclusion, voice, and greater mathematical access. This challenge is exacerbated by the "*dilemma of transparency* where the tension is between implicit and explicit teaching of the mathematics language" (Adler, 2001, p. 4, italics added). As Adler has noted, these dilemmas are a challenge for all teachers. They are not specific to a multilingual classroom. But as this paper will show, these dilemmas are more complex in a multilingual classroom where informal spoken mathematics is not in the LoLT. In these classrooms learners are acquiring English while learning mathematics.

Adler's description of the dilemmas is crucial and highlights the fundamental pedagogic tensions that cannot be resolved once and for all. However, she does not explain in specific detail why teachers experience these dilemmas in the way that they do. This focus was not her project. She posits an explanation that the dilemmas are at once personal and contextual. For instance, one of the teachers in Adler's study experienced the dilemma of mediation because of changes in her classroom and because of her personal commitment to her learners. In this paper I argue that the dilemmas that the multilingual mathematics teachers experience are also political.

The complex and competing demands on mathematics teachers in multilingual classrooms in South Africa are evident from the above discussion. Teachers have to ensure learners' access to English, to the language of mathematics, and to a range of mathematical discourses. In particular, they need to assist learners in developing formal spoken and written mathematics. These competing demands can affect classroom practices in contradictory ways, as evidenced in Adler's identification of two teacher dilemmas.

In the remainder of this paper I explore the implications of policy and the growing understanding of the complex role of language in mathematical learning as I examine research on the teaching and learning of mathematics in bi- and multilingual classrooms.

Teaching and learning mathematics in bi/multilingual classrooms

The effects of bi/multilingualism on learners have been the focus of research for decades. I will not rehearse the arguments here as they have been described in detail elsewhere (e.g., Saunders, 1988; Setati 2002). Instead, the discussion below focuses on the complex relationship between bi/multilingualism and mathematics learning as well as on code-switching as a common learning and teaching resource in many bi/multilingual classrooms in South Africa and elsewhere.

Bi/multilingualism and mathematics learning

The complex relationship between bilingualism and mathematics learning has long been recognized. Dawe (1983), Zepp (1989), Clarkson (1991), and Stephens, Waywood, Clarke, and Izard (1993) have all argued that bilingualism per se does not impede mathematics learning. Their research used Cummin's (1981) theory of the relationship between language and cognition. Cummins distinguished different levels and kinds of bilingualism. He also showed a relationship between learning and level of proficiency in both languages on the one hand and the additive or subtractive model of bilingual education used in school on the other. Secada (1992) has provided an extensive overview of research on bilingual education and mathematics achievement. He 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. Rakgokong (1994) has argued that using English only as a LoLT in multilingual primary mathematics classrooms in South Africa where English is not the main language of the learners has a negative effect on the learners' meaning making and problem solving. His study showed that, in classrooms where English was the only language used for teaching and learning, learners were able to engage in neither procedural nor conceptual discourse. Varughese and Glencross (1996) found that students at the university level had difficulty in understanding mathematical terms such as integer,

perimeter, and multiple. Their study involved first-year mathematics students in a South African university who were learning mathematics in English, which was not their main language.

This field of research has been criticized because of its cognitive orientation and its inevitable deficit model of the bilingual learner (Baker, 1993). The argument is that school performance (and by implication, mathematics achievement) is determined by a complex set of inter-related factors. Poor performance of bilingual learners thus cannot be attributed to the learners' language proficiencies in isolation from the wider social, cultural, and political factors that infuse schooling.

While I agree with the above criticism, I read into this cognitively-oriented research an implicit argument in support of the maintenance of learners' main language(s), and of the potential benefits of learners using their main language(s) as a resource in their mathematics learning. As Secada (1991) has argued, bilingualism is becoming the norm rather than the exception in urban classrooms. Hence the need in mathematics education research to examine classroom practices where the bilingual speaker is not only treated as the norm, but where 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) argues for a bilingual (or holistic) view of bilingualism in any consideration of bilinguals. This view is different from the monolingual view, which always compares the linguistic ability of bilinguals with that of monolinguals in the languages concerned. Bilinguals have a unique and specific language configuration and therefore they should not be considered as the sum of two 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 (p. 471).

In Grosjean's terms, language practices in multilingual classrooms will not be the same as in any other classroom. For example, an important aspect of multilingualism, one which makes the multilingual person an integrated whole, is code-switching. As indicated earlier, code-switching is now encouraged by the language-in-education policy. In the section below I present a review of research on code-switching in bilingual and multilingual classrooms in South Africa and elsewhere.

Code-Switching in bilingual and multilingual mathematics classrooms

Code-switching occurs when an individual alternates between two or more languages. Code-switches can be deliberate, purposeful, and political. There are important social and political aspects of switching between languages, as there are between switching between discourses, registers, and dialects. Historically, code-switching in South Africa has had an inferior status (Setati, 1998). As a result, many people still regard it as a grammarless mixture of languages. Some monolinguals see it as an insult to their own rule-governed language. It is generally believed that people who code-switch know neither language well enough to converse in either one alone. Grosjean (1982) points out that it is because of these attitudes that some bi/multilinguals prefer not to code-switch, while others restrict their switching to situations in which they will not be stigmatized for doing so. For instance, in a multilingual classroom learners may choose to switch only when interacting with other learners and not with the teacher.

Why code-switch? Even though code-switching has received substantial criticism from purists, there are researchers who see it as a valuable communication resource. On the basis of their ethnographic observation of classroom interaction in three primary schools in Kenya, Merrit, Cleghorn, Abagi, & Bunyi (1992) argue that code-switching provides an additional resource for meeting classroom needs. Poplack cited in Grosjean (1982) argues that code-switching is a verbal skill requiring a large degree of competence in more than one language, rather than a defect arising from insufficient knowledge of one or the other. Some researchers see code-switching as an important means of conveying both linguistic and social information. For instance, Gumperz cited in Grosjean (1982) maintains that code-switching is a verbal strategy, used in the same way that a skilful writer might switch styles in a short story. For instance, a teacher can use learners' main language as a code for encouragement. By using learners' main language in this manner, the teacher may implicitly be saying to learners "I am helping you; I am on your side".

In most classrooms code-switching seems to be motivated by cognitive and classroom management

factors (Adendorff, 1993; Merritt, et al., 1992): Usually it helps to focus or regain the learners' attention, or to clarify, enhance, or reinforce lesson material. Determinants of code-switching in the mathematics classroom are only partially dictated by formal language policy. Even if official policy exists, teachers make individual moment-to-moment decisions about language choice that are mostly determined by the need to communicate effectively:

> Multilingual teachers do not only teach lessons and inculcate values having to do with conservation of resources. They, perhaps unconsciously, are socialising pupils into the prevailing accepted patterns of multilingualism (Merritt, et al., p. 118).

As pointed out earlier, the language-in-education policy in South Africa recognizes eleven official languages and is supportive of code-switching as a resource for learning and teaching in multilingual classrooms. Within this policy environment that encourages switching, it is important that research focus not only on whether code-switching is used or not in the teaching and learning of mathematics but also on how and why it is used or not used.

According to Baker (1993), code-switching can be used to describe changes which are relatively deliberate and have a purpose. For example, code-switching can be used:

- to emphasize a point,
- because a word is not yet known in both languages,
- for ease and efficiency of expression,
- for repetition to clarify,
- to express group identity and status or to be accepted by a group,
- to quote someone,
- to interject in a conversation, or
- to exclude someone from an episode of conversation.

Thus code-switching has more than just linguistic properties; it can also be used for political purposes.

Researching code-switching in multilingual classrooms. Research on code-switching in multilingual classrooms in South Africa reveals that it is used for a variety of reasons. A study undertaken in primary mathematics and science classrooms in the Eastern Cape, South Africa, has shown that code-switching is used to enable both learner-learner and learner-teacher interactions (Ncedo, Peires, & Morar, 2002). Adendorff (1993), who observed non-mathematics lessons in the Kwazulu-Natal province of South Africa, found that an English teacher switched to Zulu in order to advance his explanation of the meaning of a poem. The same teacher also used code-switching as a language of provocation—he used it to raise controversial issues. Most bi/multilingual persons switch when they cannot find an appropriate word or expression or when the language being used does not have the necessary vocabulary item or appropriate translation (Grosjean, 1982). This kind of switching would occur in a bi/multilingual mathematics conversation. For instance, if learners can hold a mathematical conversation in Setswana, it is possible that the mathematical terms will be in English, because mathematics has a well-developed register in English but not in Setswana. While some of the technical mathematics terms are available in Setswana, they are not widely known and used. For instance while the Setswana word for an equilateral triangle is "khutlo-tharo-tsepa", this term is usually not used in mathematical conversations in Setswana. There are instances where the multilingual mathematics learner knows a mathematics word in both English and her main language (e.g., Setswana), but the English word becomes more available during mathematical conversations. This phenomenon can be understood because, as indicated earlier, a majority of African language speakers in South Africa learn mathematics in English.

Code-switching as a learning and teaching resource in bi/multilingual mathematics classrooms has been the focus of research in the recent past (e.g., Addendorff, 1993; Adler, 1996, 1998, 2001; Arthur, 1994; Khisty, 1995; Merritt, et al., 1992; Moschkovich, 1996, 1999; Ncedo, Peires, & Morar, 2002; Setati, 1996, 1998; Setati & Adler, 2001). These studies have presented the learners' main languages as resources for learning mathematics. They have argued for the use of the learners' main languages in teaching and learning mathematics as a support needed while learners continue to develop proficiency in the LoLT while learning mathematics. All of these studies have been framed by a conception of mediated learning, where language is seen as a tool for thinking and communicating. In other words, language is understood as a social thinking tool (Mercer, 1995). Therefore it is not surprising that problems arise when learners' main languages are not drawn on for teaching and learning. Arthur (1994) conducted her study in Botswana primary schools where the main language of the learners is Setswana. English as the LoLT starts from standard six. Her study of the use of English in standard six mathematics classrooms revealed that the absence of learners' main language (Setswana) diminished the opportunities for exploratory talk, and thus for meaning-making. The form and purposes of the teaching and learning interaction in these classrooms were constrained by the use of English only. As Arthur explains, communication was restricted to what she referred to as "final draft"

utterances in English, which were seemingly devoid of meaning.

This dominance of English is not unique to Botswana. As discussed earlier, English as the LoLT continues to dominate in multilingual classrooms in South Africa despite the new progressive language-in-education policy (Taylor & Vinjevold, 1999). In describing the code-switching practices of primary school mathematics teachers in South Africa, Setati and Adler (2001) observed the dominance of English in non-urban primary schools. They argued that in these schools English is only heard, spoken, read, and written in the formal school context, thus teachers regard it as their task to model and encourage English. Setati, Adler, Reed, and Bapoo (2002) described these school contexts as foreign language learning environments (FLLEs). They distinguish FLLEs from additional language learning environments (ALLEs), where there are opportunities for learners to acquire the English language informally outside the classroom. The English language infrastructure of ALLEs is more supportive of English as the LoLT. There is more environmental print (e.g., advertising billboards) in English, and teachers and learners have greater access to English newspapers, magazines and television, and to speakers of English. Setati, et al. (2002) found greater use of code-switching in ALLEs.

Code-switching has been observed as a "main linguistic feature in classrooms where the teacher and the learners share a common language, but ha[ve] to use an additional language for learning…the learners' language is used as a form of scaffolding" (National Centre for Curriculum and Research Development, 2000, p. 68). Adler (1996, 1998, 2001) identified code-switching as one of the dilemmas of teaching and learning mathematics in multilingual classrooms. Adler observed that in classrooms where the main language of the teacher and learners is different from the LoLT, there are ongoing dilemmas for the teacher as to whether or not she should switch between the LoLT and the learners' main language, particularly in the public domain. Another issue is whether or not she should encourage learners to use their main language(s) in group discussions or whole-class discussion. These dilemmas are a result of the learners' need to access the LoLT, as critical assessment will occur in this main language. Adler's study suggests that the dilemmas of code-switching in multilingual mathematics classrooms cannot necessarily be resolved. They do, however, have to be managed.

Moschkovich (1996, 1999) argues that bilingual learners bring into the mathematics classroom different ways of talking about mathematical objects and different points of view on mathematical situations. She emphasizes that a discourse approach can also help to shift the focus of mathematics instruction for additional language learners from language development to mathematical content. In Mercer's (1995) terms, the teacher in Moschkovich's study was a discourse guide. As Figure 1 shows, the role of the teacher as a discourse guide in a multilingual mathematics classroom involves moving learners from a stage where they can talk informally about mathematics in their main language(s) to a stage where they can use the formal language of mathematics in the LoLT (English), and can engage in procedural and conceptual mathematics discourses in English.

The above discussion demonstrates that there is a growing amount of theoretical and empirical work related to mathematics teaching and learning in bi/multilingual classrooms. The unit of study in early research on bilingualism was the bilingual learner. It is my view that this location of the problem in the learner was based on an underlying assumption of inferiority—that there is something wrong with the bilingual or multilingual learner. Recent studies have moved from focusing on the bi/multilingual learner to the bi/multilingual classroom. This change in focus drew attention to the significance of the teacher as a discourse guide in the bi/multilingual classroom, and to code-switching and the dilemmas that emerge with its use. All of the studies referred to have been framed by a conception of mediated learning, where language is seen as a tool for thinking and communication.

A different perspective on language. Language is much more than a tool for communication and thinking; it is always political (Gee, 1999). Decisions about which language to use, how, and for what purpose(s), are political. This political role of language is not dealt with in the literature on bi/multilingualism and the teaching and learning of mathematics. My own experience as a multilingual teacher and researcher in multilingual mathematics classrooms suggests that we cannot describe and explain language practices in a coherent and comprehensive way if we stop at the cognitive and the pedagogic aspects. We have to go beyond these aspects and explore the political aspects of language use in multilingual mathematics classrooms. Research so far does not capture this complexity. As mentioned earlier, Adler (2001) points to the complexity by describing dilemmas as personal and contextual, and more particularly by exploring the dilemma of code-switching. According to Adler, teachers in multilingual classrooms face a continual dilemma of whether to switch or not to switch languages in their day-to-day teaching:

> If they stick to English, students often don't understand. Yet if they "resort" to Setswana (i.e., they switch between English and Setswana) they

must be "careful", as students will be denied access to English and being able to "improve" (p. 3).

Adler (2001) describes the language practices of a teacher in her study (Thandi) as follows:

> Thandi's actions, including reformulation and repetition, were not tied simply to her pedagogical beliefs, but also to her social and historical context and her positioning within it, including her own confidence of working mathematically in English. In particular, in the South African context, where English is dominant and powerful, Thandi's decision-making and practices were constrained by the politics of access to mathematical English. Thandi might value using languages other than English in her mathematics classes to assist meaning-making. But this pedagogical understanding interacts with strong political goals for her learners, for their access, through mathematics and English, to further education and the workplace. In addition, her decision-making on code-switching inter-related in complex ways with the mathematics register on the one hand and its insertion in school mathematical discourses on the other (p. 85).

In my view, Adler partially explains Thandi's dilemma. Thandi experienced the *dilemma of code-switching* not only because of her learners and because of the pedagogical and political contexts but also because of who she is: an African mathematics teacher who shares a main language with her additional language learners. In addition Thandi saw her role not only as a mathematics teacher but also as someone who is supposed to make sure that her learners are prepared for higher education in English and the outside world. Thandi's language practices were tied up with her pedagogy, identity, and understanding of the power of English. Thandi's dilemma of code-switching is thus not only pedagogic but also political. The political and the pedagogic are in tension. This dilemma manifests itself in the multiple identities that teachers take on. For instance, politically Thandi wanted her learners to have access to English, and therefore she did not use code-switching; however, pedagogically she knew that she needed to switch so that her learners could understand and participate in the lesson.

It is clear from the above discussion that there are a growing number of studies that have focused on language use in bi/multilingual classrooms. But none of the studies focused on language as a political tool. How is language used "to enact activities, perspectives and identities" (Gee, 1999, p. ?) in bi/multilingual mathematics classrooms? The main argument of this paper is that research on the use of language(s) in multilingual mathematics classrooms needs to embrace language-in-use as a political phenomenon.

The political role of language in the teaching and learning of mathematics

In South Africa, mathematics knowledge and the English language are social goods. They are perceived to be a source of power and status. Both of them provide access to higher education and jobs. The fact that English is a language of power and socio-economic advancement in South Africa makes English a valued linguistic resource in multilingual mathematics classrooms. Even though the nine African languages now enjoy an official status, they still do not enjoy the same kind of status as English.

Gee (1999) argues that when people speak or write they create a "political" perspective; they use language to project themselves as certain kinds of people engaged in certain kinds of activity. Words are thus never just words; language is not just a vehicle to express ideas (a cultural or communicative tool), but also a political tool that we use to enact (i.e., to be recognized as) a particular "who" (identity) engaged in a particular "what" (situated activity). Thus a mathematics teacher who is also a cultural activist will have an identity that shifts and takes different shapes as she enacts her multiple identities in and through language. Her decisions about what language to use, how, when, and why will be informed by the activity and identity she wants to enact. The point here is that mathematics teachers, like all people, have multiple identities. Research that considers the use of language in multilingual mathematics classrooms only as a pedagogic and cognitive tool does not attend sufficiently to the multiple identities of multilingual teachers.

Fairclough (1995) refers to institutional and social identities. He argues that institutions impose upon people ways of talking and seeing as a condition for qualifying them to act as subjects. That is, institutions impose certain identities on people. For example, to be a mathematics teacher one is expected to master the discursive (ways of talking) and ideological (ways of "seeing") norms which the teaching profession attaches to that subject position. That is, one must learn to talk like a mathematics teacher and see things (i.e., things like learning and teaching) like a mathematics teacher. These ways of talking and seeing are inseparably intertwined in the sense that in the process of acquiring the ways of talking which are associated with a subject position, one necessarily also acquires its ways of seeing (ideological norms). Any social practice can thus be regarded as a speech and ideological community. Mathematics teaching is a speech and

ideological community. To be part of this social practice you need to talk and see things like a mathematics teacher. Any social practice imparts ways of talking and seeing that are relevant for that practice. People need this kind of shared knowledge in order to participate in that social practice. In the case of mathematics teaching, a mathematics teacher needs this kind of knowledge in order to say acceptable things in an appropriate way.

Since this shared knowledge is rooted in the practices of socio-culturally defined groups of people, Holland and Quinn as cited in D'Andrade and Strauss (1992) refer to it as culture. When talking about culture in this way, they do not refer to people's customs, artifacts, and oral traditions, but to what people must know in order to act as they do, make the things they make, and interpret their experience in the distinctive ways they do. Thus, they would argue that to be a mathematics teacher, one needs more than mathematics content knowledge—one also needs the cultural knowledge of mathematics teaching. According to Holland and Quinn, this cultural knowledge is organized into schemas that are called *cultural models.* Cultural models are taken-for-granted models of the world that guide people's actions and their expression of values and viewpoints. Gee (1999) argues that cultural models are like tapes of experiences we have had, seen, read about, or imagined. People store these tapes either consciously or unconsciously and treat some of them as if they depict prototypical (what we take to be "normal") people, objects, and events. Cultural models do not reside in people's heads. They are available in people's practices and in the culture in which they live—through the media, written materials and through interaction with others in society.

In a recent study focusing on language use in multilingual mathematics classrooms in South Africa, I have considered language practices in multilingual mathematics classrooms from a political perspective, thus attending to the multiple identities of multilingual teachers. In the study I used the notion of cultural models as an analytic tool to explore and explain the language practices of six teachers in multilingual mathematics classrooms (Setati, 2002). Since cultural models are not only inferred from what people say, but also from how they act, think, value, and interact with others (in Gee's terms, their "Discourses"), these teachers were interviewed and observed in practice.

Three categories of cultural models emerged from the analysis of the interviews and lesson transcripts in that study. *Hegemony of English* cultural models reflect the dominance of English in the teaching and learning of mathematics in multilingual classrooms. The *Policy* cultural models revealed the teachers' understanding of the language-in-education policy. The *Pedagogic* cultural models mirrored the tensions that accompany teaching mathematics to learners whose main language is not the LoLT. These multiple cultural models reveal the multiple identities that teachers enact in their multilingual classrooms to make both mathematics and English, and mathematics in English, accessible to learners. Through these three categories of cultural models, the pedagogical and the political were deeply intertwined.

English is International emerged as the "master model" (Gee, 1999). The emergence of this master model was is not surprising. The dominance of English in politics, commerce, and the media in South Africa is well known. English is seen as a key to academic and economic success, and therefore being fluent in it opens doors that are closed to vernacular speakers (Friedman, 1997). The *Hegemony of English* cultural models that emerged in this study form part of the various institutional arrangements and government policies which, as discussed earlier, have achieved the formation of an English-dominated linguistic market.

In an in-depth analysis of one of the lessons observed, English emerged as a legitimate language of communication during teaching, and thus was the language of mathematics, of learning and teaching and of assessment. However, this dominance of English produced a dominance of procedural discourse, mainly because the learners were not fluent in conceptual discourse in English. Thus whenever the teacher asked a conceptual question, they responded in procedural discourse in English, or remained silent until she changed the question into a procedural one. This dynamic is mainly due to the differing linguistic and mathematical demands of procedural discourse and conceptual discourse. In conceptual discourse learners are not only expected to know the procedure that needs to be followed to solve a problem, but also why, when, and how that procedure works. Procedural discourse, on the other hand, focuses on the procedural steps that should be followed in the solution of a problem. These steps can be memorized without understanding. Unlike conceptual discourse, procedural discourse does not require justification. It is therefore not surprising that in an additional language learning environment like the multilingual classrooms in the study, procedural discourse would dominate when mathematical conversation was in English. As illustrated earlier in Figure 1, the journey from informal spoken mathematics (in the main language) to fluency in formal spoken and written procedural and conceptual mathematics discourses in English is complex in multilingual classrooms.

What is more interesting is that the teacher whose lesson was analyzed was convinced that she was promoting multilingualism in her teaching. The

analysis shows that she used the learners' main language for regulation and solidarity. While she was regulating the learners' behavior, she also showed her support and unity with them. Her utterances in the learners' main language were encouraging and motivating to the learners. Her regulatory utterances in English, on the other hand, were more authoritative, giving instructions to and reprimanding learners. Thus the learners' main language was a voice of solidarity while English was the voice of authority.

This study has moved the dominance of English from a common-sense position to a rigorous and theoretical understanding of this dominance, and of how it plays itself out in the multilingual mathematics classroom in terms of creating mathematical opportunities for learners. This study has also revealed how the power of mathematics and English can work together in multilingual mathematics classrooms to reduce the mathematical opportunities for procedural discourse. Further, it appears that for substantial teaching and learning and engagement in conceptual discourse to occur, the learners' main languages are required. However, given the master model of *English is International*, it is not always possible to fulfill this requirement. The issue is not only that additional language learners learn mathematics in a language that is not their main one, but that the various languages used will privilege different discourses of mathematics.

Conclusion

The theoretical elaboration in this article has shown that to describe and explain language practices in multilingual mathematics classrooms, we need to go beyond the pedagogic and cognitive aspects. All language practices occur in contexts where language is a carrier of symbolic power. This aspect shapes the selection and use of language(s) and mathematical discourses. The different ways in which teachers and learners use and produce language is a function of the political structure and the multilingual settings in which they find themselves. A teacher's use of code-switching in a multilingual mathematics class is therefore not simply cognitive or pedagogic, but is also a social product arising from that particular political context.

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[1] Politics in this paper is used to refer to "anything and anyplace where human social interactions and relationships have implications for how social goods are or ought to be distributed. By social goods I mean anything that a group of people believes to be a source of power, status, or worth" (Gee, 1999, p. 2).

[2] In this paper the term African is used to refer to the majority indigenous population that speak African

languages. The so-called "coloureds" and Indians are thus not included in this category, since either English or Afrikaans is their main language.

[3] *Main language* refers to the language most often used by an individual, in which he or she becomes proficient. Some people who are fully bilingual or multilingual may use two or more languages on an approximately equal basis and thus have more than one main language. These people may choose to use one of their main languages in some contexts and the other main language in other contexts. I prefer to use the term "main language" and to avoid "first language" or "mother tongue".

Conferences 2003…

AAMT Australian Association of Mathematics Teachers http://www.aamt.edu.au/2003/info.html	Brisbane, Australia	Jan. 13–17
MAA-AMS Joint Meeting of the Mathematical Association of America and the American Mathematical Society http://www.ams.org/amsmtgs/2074_intro.html	Baltimore, MD	Jan. 15–18
AMTE Association of Mathematics Teacher Educators http://www.sci.sdsu.edu/CRSME/AMTE	Atlanta, GA	Jan. 30–Feb. 1
CERME 3 European Society for Research in Mathematics Education http://www.dm.unipi.it/~didattica/CERME3/Paper.htm	Bellaria, Italy	Feb. 28–Mar. 3
NCTM National Council of Teachers of Mathematics, Research Presession & Annual Conference http://www.nctm.org	San Antonio, TX	Apr. 7–12
Mα The Mathematical Association http://m-a.org.uk	Norwich, UK	Apr. 12–15
AERA American Educational Research Association http://www.aera.net/meeting	Chicago, IL	Apr. 21–25
PICME 10 Nordic Pre-conference to the 10th International Congress on Mathematical Education http://www.msi.vxu.se.picme10	Växjö University, Sweden	May 9–11
CMESG/GCEDM Canadian Mathematics Education Study Group/Annual Conference http://plato.acadiau.ca/courses/educ/reid/cmesg/cmesg.html	Acadia University, Nova Scotia, Canada	May 30–June 3
ICIAM International Congress on Industrial and Applied Mathematics http://www.iciam.org/iciamHome/iciamHome_tf.html	Sydney, Australia	July 7–11
XI CIAEM Eleventh Interamerican Conference on Mathematical Education http://www.furb.br/xi-ciaem	Blumenau-SC, Brazil	July 13–17
PME and PME-NA Joint International and North American Conference on the Psychology of Mathematics Education http://www.hawaii.edu/pme27	Honolulu, HI	July 13–18
JSM of the ASA Joint Statistical Meetings of the American Statistical Association http://www.amstat.org/meetings	San Francisco, CA	Aug. 3–7
GCTM Georgia Council of Teachers of Mathematics http://www.gctm.org	Eatonton, GA	Oct. 16–18
SSMA School Science and Mathematics Association http://www.ssma.org	Columbus, OH	Oct. 23–25