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Language and multilingualism in the teaching and learning of mathematics in South Africa: A review of literature in *Pythagoras* from 1994 to 2021

Authors:
Kathryn McLachlan[1]
Anthony A. Essien[1]

Affiliations:
[1]Mathematics Education Division, Wits School of Education, University of the Witwatersrand, Johannesburg, South Africa

Corresponding author:
Anthony Essien,
Anthony.Essien@wits.ac.za

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This article presents a systematic review of research on language and multilingualism in mathematics education published in the South African journal *Pythagoras* from 1994 to 2021. This time frame was chosen as the year 1994 marked the acknowledgement of 11 official languages in the new democratic South Africa (including 9 indigenous languages), compared to only Afrikaans and English during the apartheid era. The review considers emergent themes in the included articles and examines what the articles reveal about mathematics education in South Africa. In addition to other findings, our corpus of literature indicates that research in this field of mathematics has been mostly undertaken in under-resourced schools and that research under the theme of multilingual education is at the forefront of research in South African mathematics education, while research on language policy needs more attention. Research on multilingual education in our corpus of literature also reveals great awareness of the value of seeing language as a resource, as well as the benefits that accrue when learners' home languages are taken into account in mathematics teaching and learning. The gaps in research in the field of language and multilingualism in the teaching and learning of mathematics are also noted and recommendations for future research are made.

Keywords: Language and mathematics; multilingualism; language orientations; language-as-resource; language-responsive teaching.

Introduction

The attention to the intertwinement of language and mathematics, that is, how language issues are imbedded in mathematics, has gained prominence in the last couple of decades. Teaching and learning mathematics, although perhaps stereotypically associated with manipulating numbers, is now fundamentally seen as inextricably intertwined with language. Pimm and Keynes (1994) argue that 'the teaching and learning of mathematics involves the activities of *reading* and *writing*, *listening* and *discussing*' (p. 160, emphasis added), four activities that all rely on language. The intricate relationship between language and mathematics teaching has come to be seen as critical in mathematics education research over the past few decades especially in multilingual classrooms (see, for example, Morgan, Craig, Schutte, & Wagner, 2014). As the world has become more globalised, the challenges and opportunities of learning mathematics in multilingual spaces – that is, spaces where more than one language is present and presents a potential to be used (Barwell, 2016) – have come to the fore. Postcolonial countries such as South Africa are examples of contexts where these challenges and opportunities intersect in a complex manner: matters of language in mathematics classrooms go beyond reading, writing, listening and discussing, to doing so in multiple languages, against a backdrop of political change and postcolonial policies.

In South Africa, language use in (mathematics) classrooms is intricately linked to the country's political history. During the apartheid era, language-in-education policies served the agenda of the apartheid state and promoted the status of Afrikaans and English over indigenous languages. Resistance to apartheid education language policy culminated in the fatal 1976 Soweto uprisings, and addressing issues of language – both within and beyond education – was a critical point in the new democratic South Africa of the early 1990s (Adler, 2001). South Africa's Interim Constitution (1993), which was enacted in 1994, saw the acknowledgement of 11 official languages in South Africa, adding 9 indigenous languages to the previous official languages of Afrikaans and English. This was an ideological shift towards formally recognising South Africa's multilingualism which was further evident in the final Constitution of the Republic of South Africa (1996), and the Language-in-Education Policy document (Department of Education, 1997).

This language policy, still in use at the time of writing, supports multilingualism in schools. In theory, students should be taught in their first (home) language from Grade 0 to Grade 3 before English (or Afrikaans) becomes the language of learning and teaching (LoLT) from Grade 4 to Grade 12. However, this is not always the case, as even from Grade 0 many school stakeholders prefer to do mathematics in English due to its political position as a language of prestige (see Essien, 2018; Setati, 2008). Additionally, it has been argued that this policy promotes a system of multiple monolingualism in schools rather than the suggested multilingualism (Sapire & Essien, 2021).

This article undertakes a systematic review of research on language and multilingualism in mathematics education as presented in the South African journal *Pythagoras* from 1994 to 2021. The choice of this journal is due to the fact that it is the only journal in South Africa that is directly and solely focused on the teaching and learning of mathematics at all levels of education. The lower bound of this time frame was selected due to its links to the momentous political transformations that occurred in 1994, and the associated changes to language and education policy. The upper bound of 2021 is the year of writing, 28 years into South Africa's democracy. This time frame allows for the analysis of research papers written during the period of active education and language (policy) changes of the 1990s, as well as subsequent years during which these changes have been implemented and have taken root. This systematic review was thus informed by the following research questions:

- What research has been published in *Pythagoras* from 1994 to 2021 in the field of language and multilingualism as it concerns the teaching and learning of mathematics?
- What does this research reveal about language and multilingualism in mathematics education in South Africa?

In answering these research questions, we examine what research has been undertaken and published in *Pythagoras* journal since South Africa's democratic dispensation in the area of language and multilingualism in mathematics education. With the country's complex language-in-education history, we interrogate what patterns and themes are evident in the corpus of literature, how these may have changed over the 28 considered years, and what research gaps are evident.

Defining language is not straightforward. Morgan et al. (2014) argue that in a mathematics education context, language is defined in many different ways. Some definitions deal exclusively with words (spoken or written), while others include non-verbal communication, mathematical symbolism, or mathematical register (Halliday, 1974). 'Language' as a term is also used to describe natural languages used in (multilingual) classrooms. In this systematic review, however, an understanding of what constitutes language in mathematics education aligns primarily with Pimm and Keynes's (1994) activities of reading, writing, listening and discussing. The current study also reviewed papers dealing with issues related to teaching and learning in multilingual classrooms, where multilingualism is stressed in the context in which teaching and learning occur.

Language and multilingualism in mathematics education

As indicated previously, the study of language has become an active focus in (mathematics) educational research in the past few decades. As Radford and Barwell (2016) write, 'language, talk, text and the production and interpretation of symbols are integral to the creation of learning, teaching and assessment, particularly in mathematics' (p. 275). Language is the medium through which mathematical ideas can be communicated and negotiated. Mathematics, although imbedded in a natural language such as English, has come to be seen as a specialised language. Students need to learn to acquire or appropriate a mathematical register as they learn the subject (Zevenbergen, 2000) so that they can speak, hear, read and write its symbols and vocabulary with understanding. Clarkson (2009) cites various models that suggest that students progress from informal language to more mathematically structured language, and ultimately to academic mathematical language as they learn mathematics. Learning mathematics thus involves more than the simplistic view of working with numbers or algebra but is intricately bound to learning its language.

Difficulties involved in learning mathematics are compounded when this occurs in multilingual classrooms – that is, any classroom where more than one language is present, even if only one language is overtly used. Increased globalisation of the last few decades has led to teachers being 'increasingly faced with students who draw on a variety of different languages and other language practices, many of which are unfamiliar to them' (Barwell, 2016, p. 36). Multilingual classrooms have been studied globally, notably in South Africa by Adler (2001) and Setati (2005), in Australia and Papua New Guinea by Clarkson (2009, 2016), in Pakistan by Halai (2009), in Tanzania by Kajoro (2016), in the United States of America by Moschkovich (1999, 2003), and in Spain by Gorgorió and Planas (2001). Common themes in this research include the use of code switching (Adler, 2001; Halai, 2009; Setati, 2005), how to support English language learners in the mathematics classroom (Clarkson, 2009; Moschkovich, 1999), and the politics of language in multilingual classrooms. The politics of language has been highlighted in multiple settings – in particular in postcolonial countries – where it has been generally observed that English is seen as a preferred LoLT over indigenous languages due to its association with power and prestige (Adler, 2001; Clarkson, 2016; Halai, 2009; Kajoro, 2016; Setati, 2005, 2008). This leads to complexities as research has found that learning in a first language for as long as possible is most beneficial for students (King, 2003). Balancing first language and English LoLT is thus a contentious, political issue in language planning and policy (Bamgbose, 1999; Clarkson, 2016). Finally, a key additional theme in the recent

literature on multilingual mathematics education is that multilingualism is positioned as a resource in the classroom, and not as a problem (Adler, 2001; Barwell, 2018; Erath, Ingram, Moschkovich, & Prediger, 2021; Gorgorió & Planas, 2001; Moschkovich, 1999; Moschkovich & Zahner, 2018; Mostert & Roberts, 2020).

Different orientations to language

Ruiz's (1984) seminal work on language orientations in language planning, where he elaborates on three approaches to language planning, has become widely used and is useful in thinking of language issues in teaching and learning, the development of language policies, and what orientations or ideologies inform language policy and language practices. Ruiz (1984, p. 16) defines orientation as the 'complex of dispositions toward language and its role, and toward languages and their role in society', and asserts that there are three orientations towards language: language-as-problem, language-as-right, and language-as-resource. In brief, the language-as-problem orientation emphasises monolingualism and the tendency to move towards the more powerful language, and also sees multilingualism as a problem to be solved (see Planas & Setati-Phakeng, 2014; Ruiz, 1984). In South Africa, this orientation towards language supports the use of only English (or Afrikaans) in the teaching and learning of mathematics and thus sees the presence or use of other (indigenous) languages that are present in the class as problematic. The language-as-right orientation highlights the right of an individual to use one's own language without being discriminated against. While the language-as-right orientation is clearly articulated or enshrined in the Constitution of the Republic of South Africa (1996), how this translates concretely into practice has been questioned by research (see, for example, Planas & Setati-Phakeng, 2014). Finally, language-as-resource sees the presence of a multiplicity of languages not from a deficit point of view as does language-as-problem but from a resource perspective – that is, as something advantageous that should be harnessed. As Alstad and Sopanen (2020) rightly point out, in the language-as-resource orientation, multilingualism is considered as a resource not only for the linguistically marginalised, but for everyone. In the context of South Africa, this would entail seeing multilingualism as a resource not only for those whose first language is not English (LoLT in most cases) but for both those who have English as a first language and those with English as an additional language. In such a situation, using the different languages present in the class to enrich the discussions becomes of utmost importance.

Methodological approach

For this review, *Pythagoras* was selected as the source of considered research studies. *Pythagoras* is an open-access, peer-reviewed, accredited academic journal published by the Association for Mathematics Education of South Africa (AMESA). As indicated earlier, it is the only peer-reviewed accredited journal that solely focuses on mathematics education in South Africa. As our study sought to identify the extent of research on language issues and communication in mathematics education in South Africa since 1994, analysing research articles from *Pythagoras* appeared to be a useful starting point as a representative of the field.

Additionally, although *Pythagoras* has published continually since 1980, only issues since 2004 are available online. Content from 1980 to 2003 is thus much harder to examine and requires access to specialised libraries to retrieve. This review thus also sought to document research on language and communication from 1994 to 2003 that is less freely available to help make sure that it is not forgotten.

Inclusion criteria for articles

In selecting articles, we included only original research whose focus aligned with Pimm and Keynes's (1994) language and communication activities of reading, writing, listening and discussing (both in monolingual and multilingual studies). Examples of words that appeared in literature that were selected include 'speak', 'dialogue', 'discourse', 'narratives', 'language', 'multilingual', 'semiotics', 'discussion', 'listening' and 'writing' as well as names of natural languages such as 'isiZulu' or 'isiXhosa', etc. Two articles, namely Powell (1998) whose article's title includes the word 'dialogue' and Mellor, Clark and Essien (2018) whose article's title includes the word 'German', were considered but excluded from the review. This is because Powell's article discusses internal dialogue, in the sense of metacognition, while Mellor et al.'s article analyses mathematics textbooks without a focus on language. As such, both articles were deemed beyond the scope of this systematic review. In total, 31 articles were included in the corpus of literature that we analysed.

General overview of reviewed literature

Figure 1 shows the number of papers published per year. 2008 is the year with the most papers, largely influenced by the 'special issue' focusing on multilingualism in the teaching and learning of mathematics published that year. This special issue was prompted by a systematic review of literature between 2000 and 2007 on multilingualism in South Africa – a paper that was later published in 2009 (see Setati, Chitera, & Essien, 2009). This 'special issue' will be discussed in greater detail later in this article. In terms of language of writing, 30 of the research papers were written in English, with one article written in Afrikaans (Uys, 1999). In terms of context, 24 studies were situated in South Africa and 7 studies were based in other countries.

The 31 analysed papers considered a broad range of education contexts and levels, ranging from primary school to tertiary level, and including professional development situations. However, the number of articles per category varied considerably (see Table 1).

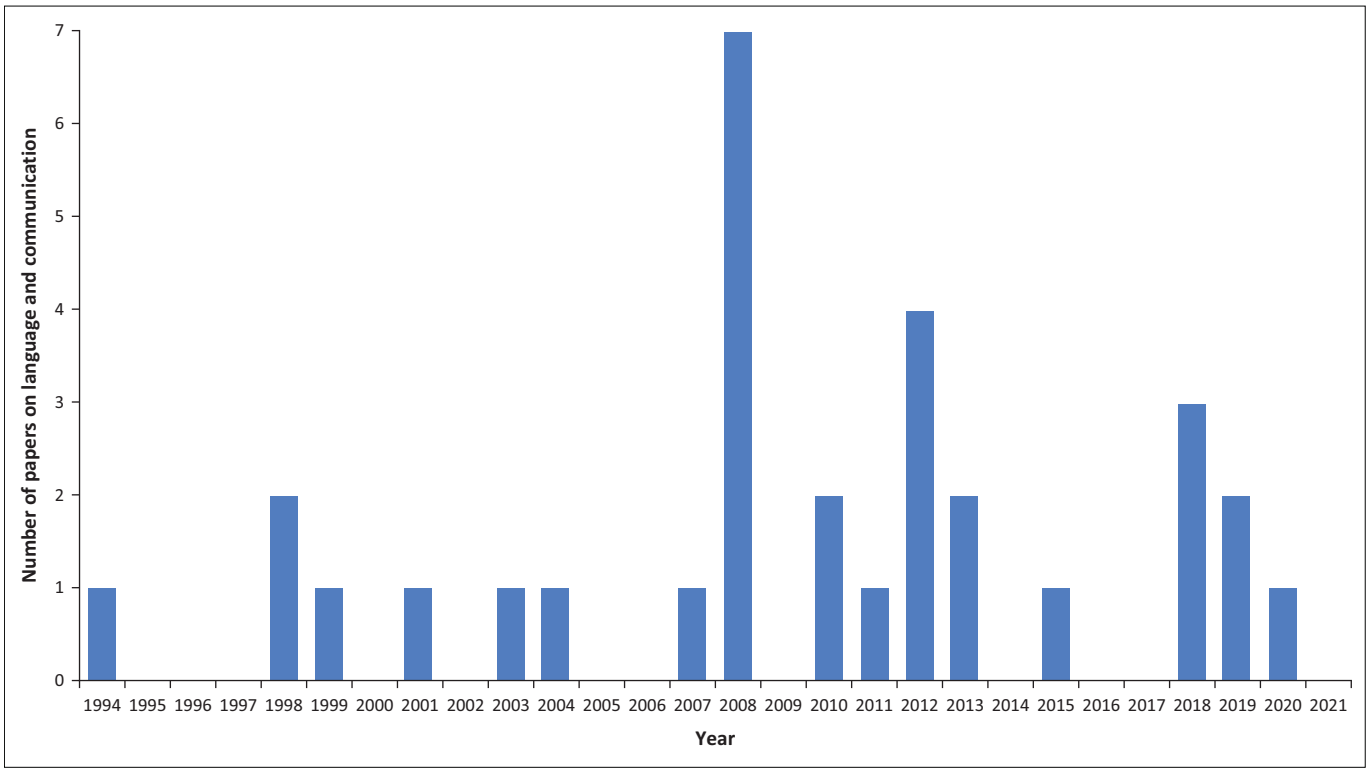

FIGURE 1: Number of papers on language and communication published in *Pythagoras* per year.

TABLE 1: Number of articles published per education context level.

Education context level	Number of articles
Primary school	4
High school	13
Both primary and high school	2
Tertiary	8
Professional development	2
Adult (other)	1
Not clear	1

Table 1 indicates that most research on language and communication in mathematics education has taken place in the high school context, with research based in tertiary institutions (both pre-service and in-service teachers) being the next most prevalent. Papers published in *Pythagoras* thus are in line with the finding described by Sapire and Essien (2021) that:

> [*in*] South Africa, although there has been ongoing reporting on the status of the LoLT in schools, there has been a dearth of research studies undertaken in early grade (Grades R to 3) mathematics classes. (p. 77)

Among the papers analysed in this review, only one paper (Mostert, 2020) considers lower primary. All the other papers on primary school are based in higher grades. It is interesting that so little research has been published (in *Pythagoras*) on lower primary school, as this is the time where in South Africa the LoLT switches from mother tongue instruction to English. Contrastingly, there appears to be a trend towards research being undertaken in tertiary institutions or in professional development situations. Over the last 10 years, of the 14 papers published, 6 were based in tertiary institutions and 2 considered in-service teacher professional development (a combined total of 57% of published papers). Only 4 papers were based on high school contexts, 1 on the primary school context, and 1 paper considered both primary and high school. It thus appears that a shift has occurred to researching situations and questions concerning prospective and practising teachers.

For the corpus of literature under the review time frame, we noted no trends in publications on the basis of how well-resourced or poorly resourced the context of research is. While some papers are theoretical or have for context teacher education – and as such were not counted in terms of resource level – we noted that none of the papers on language or multilingualism published in *Pythagoras* during our time frame had well-resourced schools as the sole context. We noted four research studies that were carried out in two or more schools wherein one was well-resourced and the other poorly resourced. Seven of the papers had under-resourced schools as their research context. This, in a way, reinforces the language-as-problem orientation as one interpretation of the lack of focus on well-resourced schools could be that these schools are framed as not having language issues although they are South African multilingual schools in their own right. Also of interest in our review of papers is which official languages are represented in research in South Africa. Our analysis revealed that 15 of the papers focused on or referenced the use of English; isiZulu and isiXhosa had 4 each; Setswana and Sesotho had 3 papers each; Afrikaans had 2 and Sepedi, Swati, Tshivenda and Xitsonga had 1 paper each. We found no paper focusing on the use of isiNdebele in the teaching and learning of mathematics.

Themes in the research

We examined all the papers and developed a summary spreadsheet and inductively coded the papers and then looked for themes. The themes emerged from reading the articles. Our analysis of the corpus of literature in *Pythagoras* under our time frame resulted in the identification of 11 areas of research. These themes are elaborated in Table 2.

Table 3 provides a summary of the 11 identified areas of research in the analysed papers. We chose to categorise each paper into only one area of research. If a paper referred to more than one of the identified areas, we only categorised it into its main (most relevant) theme based on the study's focus. For example, although Tobias's (2003) paper briefly mentions multilingual classrooms, his paper mainly examines linguistic elements of classroom mathematics. The paper was thus categorised under 'mathematics as a language'.

Two clear, predominant themes emerged based on the coding exercise: research on 'multilingual education', and research on 'speaking' in the classroom. All other themes had three or fewer papers.

Figure 2 shows the thematic patterns in our corpus of literature. Papers of the same theme have been indicated in the same colour, while themes with only a single paper have been left in white. This analysis indicates that beyond the special issue on multilingual education in 2008, there are no time-related thematic patterns that immediately stand out.

TABLE 2: Emergent themes from the surveyed research outputs.

Theme	Key focus
Multilingual education	Issues related to teaching, learning and performing in multilingual education systems, including practices in multilingual classrooms. Here, multilingualism is stressed in the context in which teaching and learning occur.
Speaking	How dialogue and discussion can influence, and occur in, mathematics education contexts, where the emphasis is on spoken words.
Discourse	The interplay between mathematical talk, words, actions or writing in various mathematics education contexts, including Venkat and Adler's (2012) mathematical discourse in instruction framework.
Natural-language specific	Issues related to communicating, teaching and learning mathematics in a particular natural language (in comparison to a focus on a multilingual context).
Semiotics	Mathematical signs and symbols, how these form part of meaning making, as well as the different modalities in which these can occur.
Listening	The influence that listening can have in mathematics education contexts.
Mathematics as a language	The relationship between language and mathematics and how this can affect the teaching and learning of mathematics.
Reading	The relationship between reading and mathematical knowledge, including non-mathematical texts.
Terminology	The importance of understanding mathematical terminology to solve mathematical problems.
Visual communication	The effect of visualisation on mathematical reasoning and understanding.
Writing	The relationship between writing and mathematical knowledge.

What can be seen, however, is that in the last 10 years (since 2011), four articles that link to 'speaking' and three articles that link to 'discourse' have been published. Beyond this, there are no clear time-based trends.

In the following section, we examine the themes as indicated in Table 3. We first consider themes with three or fewer papers, before looking more specifically at the themes with greater focus, mainly 'multilingual education' and 'speaking'. In some cases, we use the language orientation framework by Ruiz (1984) discussed above to interpret the orientation to language evident in the body of literature. In our discussion of each article, we also indicate if the research is *not* based on the South African context.

Reading, terminology, visual communication and writing

We found a total of four papers (one each) for these themes. For *reading*, Mwale and Mwakapenda (2018) explore the relationship between reading and mathematics through an investigation on the extent to which students can see mathematics in non-mathematical texts. They find that students struggle to identify mathematics in texts where they would classically not be looking for mathematical content. For *terminology*, Atebe and Schäfer (2010) examine high school students' (in Nigeria and South Africa) proficiency of geometry vocabulary against a backdrop of the Van Hiele theory of levels of geometry understanding. They find that the participating students had low ability in basic geometry terminology, and that verbal geometry ability has a high correlation with the ability to work with visual problems based on the same terminology. Also based in geometry, for *visual communication*, Mudaly (2010) examines the role that visualisation plays in developing mathematical understanding and reasoning. The study illustrates how using visualisation tools (here, Sketchpad) can quicken the process of reasoning and testing conjectures in geometry-based problem-solving. Finally, for *writing*, US-based Powell (2001) explores the use of student writing as a means by which teachers can access, examine and respond to students' internal mathematical thinking. The diverse content of these four papers shows the ubiquitous nature of language and how it relates to mathematics teaching and learning in diverse ways. However, it is hardly surprising that there is limited attention given to issues of reading, writing and English terminology use in our extant literature. Given the multilingual context in which teaching and learning are imbedded in South Africa, the focus of research (as evident in Table 3) has been on multilingual issues rather than language issues in relation to English use.

Listening, and mathematics as a language

We found two papers each under the themes of listening and mathematics as a language. Both papers on *listening*, namely

TABLE 3: Number of papers per area of research.

Multilingual education	Speaking	Discourse	Natural-language specific	Semiotics	Listening	Mathematics as a language	Reading	Terminology	Visual communication	Writing
9	5	3	3	3	2	2	1	1	1	1

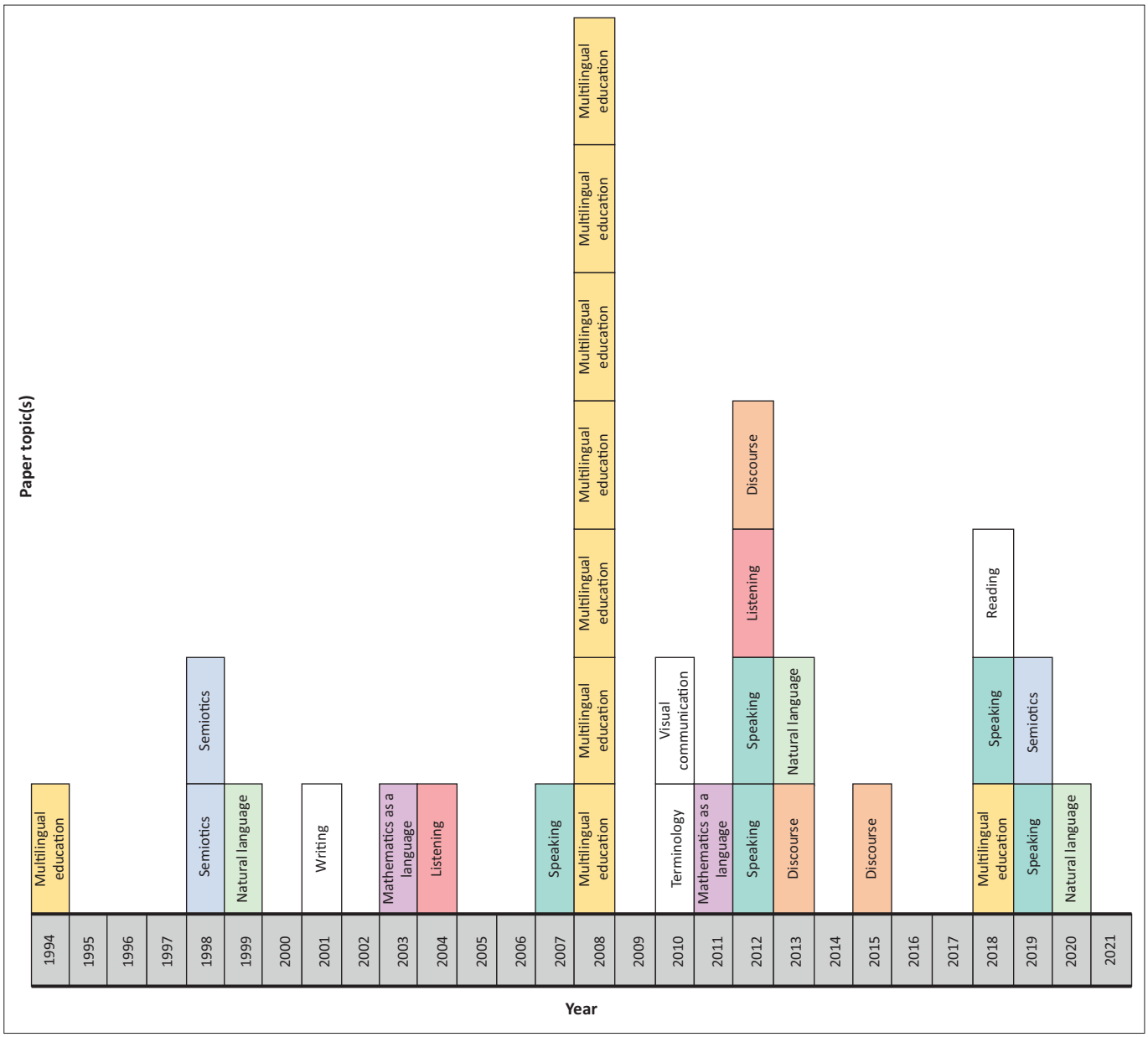

FIGURE 2: Paper topics per year.

Breen (2004) and Mhlolo and Schäfer (2012), reference Davis's (1997) three listening styles of evaluative, interpretive and hermeneutic listening. However, these types of listening are used differently in both papers. For Breen, listening is considered as a means of assessment. For Mhlolo and Schäfer, listening is regarded as an indicator of the levels of democracy present in a mathematics classroom. Although Breen's article focuses on listening, the discussed research context uses written journals as a means of accessing his students' thinking in a similar way as described by Powell (2001). In terms of *mathematics as a language*, Tobias's (2003) paper considers the complexities of mathematical register such as vocabulary, semantic structure (how the meaning ascribed to a text points to particular mathematical operations or relationships)[1], and lexical density (the ratio of content-related (mathematics-related) words to grammatical words in a given text)[2]. He argues that it is crucial for teachers to understand the complex linguistic aspects of the mathematics classroom so that they can support their students to navigate the language of mathematics. Patkin's (2011) paper considers the interplay of mathematical and everyday language in an Israeli teacher training context. In her work, everyday language is seen as both a resource and a problem. She describes exercises undertaken using non-mathematical literature to heighten pre-service teachers' awareness of words that carry multiple

1.For example, drawing on other researchers, Zevenbergen (2000) argues that in an additive change problem which can be formulated as 3 + 2 = *x (Lebo has 3 oranges, then she got 2 more. How many oranges does Lebo now have?)* is less complex for students than if the unknown is the first variable as in *x* + 2 = 5 *(Lebo has 2 oranges more than Thabo. In total, there are 5 oranges. How many oranges does Thabo have?)*. While both are about the equation 2 + 3 = 5, the first has a combine semantic structure, the second has a compare semantic structure. Zevenbergen argues that wording a question to make the semantic structure familiar to learners may help learners better solve the problem but does not help learners in cracking the code of the mathematics register.

2.As such, a mathematics question with a higher content-grammar ratio is considered to be lexically dense and more difficult to read, which can mean that the question can be found to be more difficult for learners.

meanings within mathematical and everyday language. Her work thus overlaps to a limited degree with that of Mwale and Mwakapenda (2018) by using written texts that would classically be deemed non-mathematical in conjunction with mathematical content.

Discourse and speaking

Our corpus of literature revealed three papers under the theme of *discourse*. Venkat and Adler (2012) discuss *teacher* discourse through the lens of mathematical discourse in instruction (MDI). Their article examines and defines teachers' MDI, which includes the mathematical features of teachers' talk, actions and writing as they interact with students. The authors develop analytical language to examine how coherently a teacher moves from a stated mathematical problem towards a solution. Lampen (2015) uses the concept of MDI to explore required teacher knowledge and skill to meaningfully conduct classroom discussions on the statistical mean algorithm in a connected manner. Contrastingly, Berger (2013) examines *student* discourse from the perspective of Sfard's theory of commognition. Her article highlights the importance of words when discussing mathematical phenomena as indicators of (developing) student understanding. This highlights the importance of instructors carefully listening to student discourse as a means of accessing their understanding.

For *speaking*, our analysis categorised five papers. In different ways, these articles make clear the opportunities for learning that are inherent in group dialogue, and the vital role of the discussion facilitator in this process. Brodie (2007) considers classroom dialogue and how to create opportunities for learner talk and participation. She argues that the teacher-led Initiation-Response-Feedback (IRF) model does not create rich classroom discussion and proposes various alternatives to create genuine student dialogue. Sepeng and Webb (2012) explore the use of discussion as a teaching strategy. Using carefully considered teacher-led discussion techniques, focusing on reasoning, their study indicates improvement in student problem-solving performance and ability to make sense of real-world word problems. Contrastingly, Daher (2012) considers Palestinian pre-service teachers' perceptions of democracy within the mathematics classroom, of which dialogue is a key element. The students considered the didactic communication acts of discussing, asking, arguing, and listening as part of democratic dialogue (classroom) practice. Within the context of one professional learning community, Chauraya and Brodie (2018) analyse group conversations for learning opportunities. Their study indicates that facilitator-led group conversations create opportunities for participating teachers to develop their knowledge. In particular, the study positions the facilitator as crucial in creating these learning opportunities. Finally, also within the sphere of professional development, Gierdien, Smith and Julie (2019) consider different ways in which university researchers and classroom teachers talk of, understand and work with the (same) teaching and learning of mathematics. They find that using 'toolkits' can anchor conversations and help university-based mathematics educators to bridge the gap of contrasting discursive practices.

It is significant to note that talk in the mathematics classroom has enjoyed a good deal of attention in our selection of literature as creating a classroom where there is productive disciplinary engagement (Engle & Conant, 2002) is a key focus of research on language and mathematics in global research in recent years.

Semiotics and natural language

Our corpus of literature revealed three papers in each of the themes 'semiotics' and South African national languages. For semiotics, Ernest's (1998) article examines links between mathematical written signs and their meanings. This involves a complex interplay between signifiers and signifieds, with meanings existing in both private 'maths words' of the student and publicly between the student and the teacher or researcher. Vile's (1998) article, on the other hand, interrogates the popularity of semiotics in mathematics education at the time of writing. He argues that semiotics provides a framework to analyse meaning making that allows for systematic interpretation of classroom events for both researchers and teachers. Both these studies are UK-based. Finally, Ubah and Bansilal (2019) examine semiotic representation as part of reasoning in Euclidean geometry. Their study finds that some pre-service teachers struggle to move between visual and symbolic registers of representation, and that concrete manipulatives can be helpful in bridging this gap. These findings link to Mudaly's (2010) paper, with both cases suggesting that manipulatives can be helpful in developing geometric reasoning.

Finally, three papers discuss mathematical issues related to natural language. Uys (1999) considers the difference in number structures in Afrikaans and other South African languages, highlighting English, and how this can cause difficulties for Afrikaans additional language learners. Van Laren and Goba (2013), on the other hand, examine the effects of developing isiZulu versions of various postgraduate Certificate in Education courses normally taught in English. They find that, although the isiZulu courses were generally well received, difficulties were encountered with isiZulu mathematics register, and having to translate English research paper content into isiZulu for assignments. It additionally became apparent that, socially, isiZulu instruction was seen as of a lower status than English instruction, although the course content was identical. Lastly, Mostert (2020) investigates isiXhosa word problems in Grade 1–3 classrooms. She examines the relative difficulty of different compare-type problems in isiXhosa and how the isiXhosa wording can affect how students experience the problem's level of difficulty. Mostert points to the importance of studying how African languages convey mathematical ideas to better understand the learning affordances of tasks. While the work of Uys is orientated towards language-as-problem, Van Laren and Goba and Mostert both work with the language-as-resource orientation. The work under the theme of natural language relates to the work on multilingual education, to which we now turn.

Multilingual education

The most prevalent theme in our corpus of literature is multilingual education. The earliest paper in this theme is Rakgokong (1994) who wrote amid political change in South Africa. Rakgokong argues that language policy must be informed by research and have a child's ability to perform at heart. He strongly argues against English being the sole LoLT for mathematics in higher grades, particularly in constructivist classrooms where meaning is developed through discussion and negotiation. The next six articles all stem from *Pythagoras*'s special issue on multilingual classrooms published in 2008. As indicated previously, this issue was motivated by the paucity of research on multilingual classrooms published in *Pythagoras* as described in Setati et al. (2009). In the South African context, the majority of students learn mathematics in an additional language making this topic particularly relevant and necessary to be covered in a local journal (Setati & Barwell, 2008). Two papers in this issue consider matters of education policy. Dlamini's (2008) article considers language issues regarding university entrance in Eswatini. He argues that Eswatini university language policies require English proficiency for acceptance into science degrees, although English ability is not a predictor of mathematical ability. As such, he suggests that these policies discriminate against the indigenous population, and fail mathematically gifted students who struggle with English language. Kazima (2008), on the other hand, investigates different ways in which countries have developed mathematical registers in indigenous languages. Nigeria and Tanzania have developed 'new' terminology while Malawi has borrowed words from English. She discusses the strengths of weaknesses of these contrasting policy decisions. Three articles in this issue consider matters relating to code switching. Setati, Molefe and Langa (2008) investigate how to use indigenous languages in the mathematics classroom without compromising the development of crucial English language skills. Their study indicates that having access to mathematical tasks in both English and a student's main language is beneficial to the student. They argue that it is simplistic to think that mathematics classrooms should function in only one language. Webb and Webb (2008) examine code switching as a means of promoting exploratory talk. They contend that in English LoLT multilingual classrooms, where English proficiency is low, students do not engage in much talk, with teachers using IRF cycles. By using code switching as an element of exploratory talk, their paper describes how some teachers experienced success in achieving more student talk in their classrooms. Vorster (2008) investigates how the use of multilingual material (a glossary, as well as providing test questions in English and Setswana) can aid the code switching process. This study indicates that students benefit from having both languages available in their material. Finally, Bohlmann and Pretorius (2008) investigate how in multilingual classrooms reading and language ability correlates to mathematical ability and find that mathematical performance is closely linked to reading capability. It is thus argued that poor literacy will affect mathematical learning. Beyond the special issue, two final articles deal with multilingual issues. Brijlall (2008) explores collaborative learning in multilingual classrooms and shows that students who worked in groups, where any language could be used for communication, performed better than students working individually. Finally, Ledibane, Kaiser and Van der Walt (2018) consider the similarities in acquiring English as a second language, and mathematics 'as a second language' and argue that both can be acquired simultaneously. In terms of orientation towards language, like two papers in the theme of natural language, there is an orientation towards language-as-resource in all the papers under the theme of multilingual education. This is in line with international trends where, more and more, language is conceived of as a resource rather than a problem.

Discussions and concluding remarks

The findings of this systematic review indicate that language and multilingual issues have been a regular part of *Pythagoras* journal since 1994. In general, interest in these topics has increased substantially in the second half of this time frame (8 articles before 2008; 23 articles from 2008). This trend is mirrored in the locally based research, with six articles published before 2008 and 18 from 2008.

More specifically, the extant literature also indicates that multilingual issues are at the forefront of research involving language in South African mathematics education. This is in line with the country's multilingual context. Research (for example, Adler, 2001; Moschkovich, 1999; Setati, 2005) has since noted that teaching and learning in multilingual classrooms is complex, and various articles in this review (Brijlall, 2008; Setati et al., 2008; Vorster, 2008; Webb & Webb, 2008) investigate methods for practising teachers to take on these complexities with increased success. What is surprising, however, is that beyond the special issue on multilingual classrooms which contributes six articles, only three articles have been published on multilingual education. Should the special issue not have been published, multilingual education would thus be a minor theme in this review. Setati et al. (2009) question the lack of research on multilingual education in the South African context (between 2000 and 2007) and posit that it may be the combined effect of the inter-disciplinary demands, necessity of multilingual research teams, and the political nature of this topic that renders it unpopular even though it is crucial. These reasons could be extended to *Pythagoras*.

It was also somewhat surprising to us to find few papers dealing with terminology in mathematics education, given that the issue of the importance of terminology as part of the mathematics register has always been a contentious issue in South Africa. What also remains to be done with regard to multilingual issues is to pay some attention to translanguaging as a practice in its own right, or *vis-à-vis* code switching. Code switching is generally seen as the use of two or more languages within a single interaction. As Barwell (2016) notes, for much of the research on code switching, the analytical focus is on the languages as distinct, one from the other. What this means for research as Barwell (2016) contends is that:

> a strong focus on distinct languages may … lead to the arbitrary separation in research and policy of multilingual mathematics classrooms in which only one language is used, from those in which two or more are used. (p. 29)

This view of language as discrete and distinct is termed *monoglossia* and it excludes any consideration that, in reality, both teachers and learners have multilingual communicative repertoires that can be drawn upon with fluidity and flexibility. This brings us to translanguaging. García and Wei (2014) define translanguaging as:

> the enaction of language practices that use different features that had previously moved independently constrained by different histories, but that now are experienced against each other in speakers' interaction as one *new* whole. (p. 21, [*italics in original*])

Rather than focus on the languages an individual speaks as distinct, one from the other, translanguaging posits that the languages with which learners and teachers come to school are fluid and flexible rather than codes between which the code switcher moves back and forth. As such, the language practices that become the focus of research on code switching for multilingual classrooms are different from what could be the focal point for research on translanguaging.

Another visible gap in our corpus of literature is research dealing overtly with matters of language policy in South Africa. Of the analysed papers, only four focus on issues of policy (Dlamini, 2008; Kazima, 2008; Rakgokong, 1994; Van Laren & Goba, 2003), with Dlamini and Kazima's (2008) work based internationally. Rakgokong's (1994) paper, published during South Africa's stark political changes, calls for language policy of the new dispensation to be flexible and informed by education research for the child's well-being and learning. Van Laren and Goba's (2013) article, on the other hand, investigates the enactment of language policy for higher education by promoting isiZulu as an instruction medium. In both papers, a common theme is the lower perceived 'status' of education in indigenous languages compared to English, reflecting similar findings in the literature at large. Matters of language policy are, of course, implicitly present in research on multilingual classrooms and Bohlmann and Pretorius (2008) and Setati et al. (2008) both briefly speak towards policy (more directly than other analysed papers on multilingual classrooms). However, overall, it is surprising that in the South African context of political change and linguistic diversity, no papers directly focusing on language-in-education policy for Grade 0–12 have been published since 1994 in *Pythagoras*. Since studies on language planning and policy implementation are widespread in South Africa, it would be worthwhile to have research that focuses on the integration of studies on language policy implementation in terms of how this (research) has in turn shaped language policies and teaching practices. For example, findings of successful use of talk and materials in more than one language (Setati et al., 2008; Vorster, 2008) could be used as a foundation of a more *flexible* language policy (suggested by Rakgokong, 1994) that takes into account translanguaging as a practice and how translanguaging can better serve the needs of multilingual classrooms.

While it was not always easy for us to decipher clear trends in terms of the theoretical orientations in the corpus of literature, or in terms of the political orientations towards language (language-as-problem, language-as-right, language-as-resource), our review has revealed that in terms of the context of study, there was more research in under-resourced schools than in well-resourced schools. As indicated previously, this indicates an orientation towards language-as-problem. However, this is countered by the research on multilingual education in our corpus of literature, which indicates a great awareness of the value of seeing language as a resource, as well as the benefits that accrue when taking learners' home languages into account in mathematics teaching and learning.

International trends in language and multilingual issues in the teaching and learning of mathematics are shifting to language-responsive teaching of mathematics (Erath & Prediger, 2021; Erath et al., 2021; Essien, Chitera, & Planas, 2016; Prediger, 2019; Prediger & Neugebauer 2021), which advocates for the development of the necessary knowledge and practices needed for the integration of 'mathematics and language learning in a mathematics-specific way' (Prediger, 2019, p. 368). Such research, which draws on the resource orientation to language, will entail, among others, empirical research that takes into account both the communicative and the epistemic functions of language as tools for thinking and knowledge acquisition (Prediger, 2019).

Our corpus of literature also revealed that some languages are more represented in research than others. Of note is that there was no research that referenced the isiNdebele language. While this is a gap in research, a more notable gap is the lack of research in the so-called non-official languages in South Africa. While there may be 11 official languages in South Africa, the reality is that South Africa boasts of other languages that are not recognised as official. For example, there are the Setlokwa and Selobedu languages in Limpopo, Sepulana in Mpumalanga, to mention but a few. Early grade learners and teachers in these areas have to grapple with the added issue of teaching and learning in an indigenous language that is different to their home language. Research into how these minority (or unofficial) language teachers and learners experience the teaching and learning of mathematics will certainly go a long way in informing the debates around language and multilingual issues in the teaching and learning of mathematics in South Africa.

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Authors' contributions

K.M. produced the first draft. Both K.M. and A.A.E. reconceptualised the data analysis and methodology after the original draft was produced. Both A.A.E. and K.M. analysed the extant literature and contributed to the discussions section of the article.

Ethical considerations

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Disclaimer

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References

Adler, J. (2001). *Teaching and learning mathematics in multilingual classrooms*. Dordrecht: Kluwer Academic Publishers.

Alstad, G.T. & Sopanen, P. (2020). Language orientations in early childhood education policy in Finland and Norway. *Nordic Journal of Studies in Educational Policy, 7*(1), 30–43. https://doi.org/10.1080/20020317.2020.1862951

Atebe, H.U., & Schäfer, M. (2010). Beyond teaching language: Towards terminological primacy in learners' geometric conceptualisation. *Pythagoras*, *71*, 53–64. https://doi.org/10.4102/pythagoras.v0i71.7

Bamgbose, A. (1999). African language development and language planning – Language and development in Africa. *Social Dynamics, 25*(1), 13–30. https://doi.org/10.1080/02533959908458659

Barwell, R. (2016). Mathematics education, language and superdiversity. In A. Anjum & P. Clarkson (Eds.), *Teaching and learning mathematics in multilingual classrooms: Issues for policy, practice and teacher education* (pp. 25–39). Rotterdam: Sense Publishers.

Barwell, R. (2018). From language as a resource to sources of meaning in multilingual mathematics classrooms. *The Journal of Mathematical Behavior*, *50*, 155–168. https://doi.org/10.1016/j.jmathb.2018.02.007

Berger, M. (2013). Examining mathematical discourse to understand in-service teachers' mathematical activities. *Pythagoras*, *34*(1), 1–10. https://doi.org/10.4102/pythagoras.v34i1.197

Bohlmann, C., & Pretorius, E. (2008). Relationships between mathematics and literacy: Exploring some underlying factors. *Pythagoras*, *67*, 42–55. https://doi.org/10.4102/pythagoras.v0i67.73

Breen, C. (2004). Perturbating the assessment of individuals and groups: Listening for challenges to mathematics teacher educators. *Pythagoras*, *60*, 2–12. https://doi.org/10.4102/pythagoras.v0i60.121

Brijlall, D. (2008). Collaborative learning in a multilingual class. *Pythagoras*, *68*, 52–61. https://doi.org/10.4102/pythagoras.v0i68.67

Brodie, K. (2007). Dialogue in mathematics classrooms: Beyond question-and-answer methods. *Pythagoras*, *66*, 3–13. https://doi.org/10.4102/pythagoras.v0i66.75

Chauraya, M., & Brodie, K. (2018). Conversations in a professional learning community: An analysis of teacher learning opportunities in mathematics. *Pythagoras*, *39*(1), 1–9. https://doi.org/10.4102/pythagoras.v39i1.363

Clarkson, P. (2016). The intertwining of politics and mathematics teaching in Papua New Guinea. In A. Anjum & P. Clarkson (Eds.), *Teaching and learning mathematics in multilingual classrooms: Issues for policy, practice and teacher education* (pp. 25–39). Rotterdam: Sense Publishers.

Clarkson, P.C. (2009). Mathematics teaching in Australian multilingual classrooms: Developing an appropriate approach to the use of classroom languages. In R. Barwell (Ed.) *Multilingual mathematics classrooms: Global perspectives* (pp. 129–145). Bristol: Multilingual Matters.

Daher, W. (2012). Student teachers' perceptions of democracy in the mathematics classroom: Freedom, equality and dialogue. *Pythagoras*, *33*(2), 1–11. https://doi.org/10.4102/pythagoras.v33i2.158

Davis, B. (1997). Listening for differences: An evolving conception of mathematics teaching. *Journal for Research in Mathematics Education*, *28*(3), 355–376. https://doi.org/10.2307/749785

Department of Education. (1997). *Language in education policy*. Retrieved from http://education.pwv.gov.za/policies%20and%20Reports/Policies/Language

Dlamini, C. (2008). Policies for enhancing success or failure? A glimpse into the language policy dilemma of one bilingual African state. *Pythagoras*, *67*, 5–13. https://doi.org/10.4102/pythagoras.v0i67.69

Engle, R.A., & Conant, F.R. (2002). Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom. *Cognition and Instruction*, *20*(4), 399–483. https://doi.org/10.1207/S1532690XCI2004_1

Erath, K., Ingram, J., Moschkovich, J., & Prediger, S. (2021). Designing and enacting teaching that enhances language in mathematics classrooms. *ZDM Mathematics Education, 53*(2), 245–262. https://doi.org/10.1007/s11858-020-01213-2

Erath, K., & Prediger, S. (2021). Quality dimensions for activation and participation in language-responsive mathematics classrooms. In N. Planas, M. Schütte, & C. Morgan (Eds.), *Classroom research on mathematics and language – Seeing learners and teachers differently* (pp. 167–183). London: Routledge.

Ernest, P. (1998). Mathematical activity and rhetoric: A semiotic analysis of an episode of mathematical activity. *Pythagoras*, *45*, 6–10.

Essien, A.A. (2018). The role of language in the teaching and learning of early grade mathematics: An 11-year account of research in Kenya, Malawi and South Africa. *African Journal of Research in Mathematics, Science and Technology Education*, *22*(1), 48–59. https://doi.org/10.1080/18117295.2018.1434453

Essien, A.A., Chitera, N., & Planas, N. (2016). Language diversity in mathematics teacher education: Challenges across three countries. In R. Barwell, P. Clarkson, A. Halai, M. Kazima, J. Moschkovich, N. Planas, … M. Villavicencio Ubillús (Eds.), *Mathematics education and language diversity* (pp. 103–119). Cham: Springer.

García, O., & Wei, L. (2014). *Translanguaging: Language, bilingualism and education*. Basingstoke: Palgrave Macmillan.

Gierdien, F., Smith, C., & Julie, C. (2019). Keeping sites in sight: Conversations with teachers about the design of toolkits peculiar to a continuous professional development initiative. *Pythagoras*, *40*(1), 1–11. https://doi.org/10.4102/pythagoras.v40i1.475

Gorgorió, N., & Planas, N. (2001). Teaching mathematics in multilingual classrooms. *Educational Studies in Mathematics*, *47*, 7–33. https://doi.org/10.1023/A:1017980828943

Halai, A. (2009). Politics and practice of learning mathematics in multilingual classrooms: Lessons from Pakistan. In R. Barwell (Ed.), *Multilingual mathematics classrooms: Global perspectives* (pp. 33–47). Bristol: Multilingual Matters.

Halliday, M.A.K. (1974). *Some aspects of sociolinguistics*. *Interactions between linguistics and mathematical education symposium*. Paris: United Nations Educational Scientific and Cultural Organization.

Kajoro, P. (2016). Transition of the medium of instruction from English to Kiswahili in Tanzanian primary schools. In A. Anjum & P. Clarkson (Eds.), *Teaching and learning mathematics in multilingual classrooms: Issues for policy, practice and teacher education* (pp. 25–39). Rotterdam: Sense Publishers.

Kazima, M. (2008). Mother tongue policies and mathematical terminology in the teaching of mathematics. *Pythagoras*, *67*, 56–63. https://doi.org/10.4102/pythagoras.v0i67.74

King, L. (Ed.), (2003). *Education in a multilingual world*. Paris: United Nations Educational Scientific and Cultural Organization (UNESCO).

Lampen, E. (2015). Teacher narratives in making sense of the statistical mean algorithm. *Pythagoras*, *36*(1), 1–12. https://doi.org/10.4102/pythagoras.v36i1.281

Ledibane, M., Kaiser, K., & Van der Walt, M. (2018). Acquiring mathematics as a second language: A theoretical model to illustrate similarities in the acquisition of English as a second language and mathematics. *Pythagoras*, *39*(1), 1–12. https://doi.org/10.4102/pythagoras.v39i1.347

Mellor, K., Clark, R., & Essien, A.A. (2018). Affordances for learning linear functions: A comparative study of two textbooks from South Africa and Germany. *Pythagoras*, *39*(1), 1–12. https://doi.org/10.4102/pythagoras.v39i1.378

Mhlolo, M.K., & Schäfer, M. (2012). Towards empowering learners in a democratic mathematics classroom: To what extent are teachers' listening orientations conducive to and respectful of learners' thinking? *Pythagoras*, *33*(2), 1–9. https://doi.org/10.4102/pythagoras.v33i2.166

Morgan, C., Craig, T., Schütte, M., & Wagner, D. (2014). Language and communication in mathematics education: An overview of research in the field. *ZDM Mathematics Education*, *46*(6), 843–853. https://doi.org/10.1007/s11858-014-0624-9

Moschkovich, J. (1999). Supporting the participation of English language learners in mathematical discussions. *For the Learning of Mathematics, 19*(1), 11–19.

Moschkovich, J. (2003). What counts as mathematical discourse? In N. Pateman, B. Dougherty, & J. Zilliox (Eds.), *Proceedings of the 2003 joint meeting of PME and PMENA, Volume 3* (pp. 325–331). University of Hawaii: Honolulu, HI.

Moschkovich, J., & Zahner, W. (2018). Using the academic literacy in mathematics framework to uncover multiple aspects of activity during peer mathematical discussions. *ZDM Mathematics Education*, *50*, 999–1011. https://doi.org/10.1007/s11858-018-0982-9.

Mostert, I., & Roberts, N. (2020). Diversity of mathematical expression: The language of comparison in English and isiXhosa early grade mathematics texts. *Research in Mathematics Education*, 1–21. https://doi.org/10.1080/14794802.2020.1821757

Mostert, I.E. (2020). Relative difficulty of early grade compare type word problems: Learning from the case of isiXhosa. *Pythagoras*, *40*(1), 1–16. https://doi.org/10.4102/pythagoras.v41i1.538

Mudaly, V. (2010). Thinking with diagrams whilst writing with words. *Pythagoras*, *71*, 65–75. https://doi.org/10.4102/pythagoras.v0i71.8

Mwale, L., & Mwakapenda, W. (2018). 'Eighteen hands high': A narrative reading of Animal Farm from a mathematical perspective. *Pythagoras*, *39*(1), 1–10. https://doi.org/10.4102/pythagoras.v39i1.403

Patkin, D. (2011). The interplay of language and mathematics. *Pythagoras*, *32*(2), 1–7. https://doi.org/10.4102/pythagoras.v32i2.15

Planas, N. & Setati-Phakeng, M. (2014). On the process of gaining language as a resource in mathematics education. *ZDM*, *46*, 883–893. https://doi.org/10.1007/s11858-014-0610-2

Pimm, D., & Keynes, M. (1994). Mathematics classroom language: Form, function and force. In R. Biehler, R. Sholz, R. Straber & B. Winkelmann (Eds.), *Didactics of mathematics as a scientific discipline* (pp. 159–169). Dordrecht: Kluwer.

Powell, A.B. (1998). Forcing awareness of mathematics: Self, mind and content in dialogue. *Pythagora*s, *45*, 36–39.

Powell, A.B. (2001). Capturing, examining, and responding to mathematical thinking through writing. *Pythagora*s, *55*, 3–8.

Prediger, S. (2019). Investigating and promoting teachers' expertise for language-responsive mathematics teaching. *Mathematics Education Research Journal, 31*, 367–392. https://doi.org/10.1007/s13394-019-00258-1

Prediger, S., & Neugebauer, P. (2021). Capturing teaching practices in language-responsive mathematics classrooms Extending the TRU framework 'teaching for robust understanding' to L-TRU. *ZDM Mathematics Education 53*, 289–304. https://doi.org/10.1007/s11858-020-01187-1

Radford, L., & Barwell, R. (2016). Language in mathematics education research. In Á. Gutiérrez, G.C. Leder, & P. Boero (Eds.), *The second handbook of research on the psychology of mathematics education* (pp. 275–313). Rotterdam: Sense Publishers.

Rakgokong, L. (1994). Communicating in English for mathematics problem solving: The case of bilingualism. *Pythagoras*, *35*, 14–19.

Ruiz, R. (1984). Orientations in language planning. *NABE Journal*, *7*(2), 15–34. https://doi.org/10.1080/08855072.1984.10668464

Sapire, I., & Essien, A. (2021). Multiple monolingualism versus multilingualism? Early grade Mathematics teachers' and students' language use in multilingual classes in South Africa. In A.A. Essien & A. Msimanga (Eds.), *Multilingual education yearbook 2021: Policy and practice in STEM multilingual contexts* (pp. 75–95). Cham: Springer.

Sepeng, P., & Webb, P. (2012). Exploring mathematical discussion in word problem-solving. *Pythagoras*, *33*(1), 1–8. https://doi.org/10.4102/pythagoras.v33i1.60

Setati, M. (2005). Teaching mathematics in a primary multilingual classroom. *Journal for Research in Mathematics Education*, *36*(5), 447–466.

Setati, M. (2008). Access to mathematics versus access to the language of power: The struggle in multilingual mathematics classrooms. *South African Journal of Education, 28*, 103–116.

Setati, M., & Barwell, R. (2008). Making mathematics accessible for multilingual learners [Guest Editorial]. *Pythagoras*, *67*, 2–4. https://doi.org/10.4102/pythagoras.v0i67.68

Setati, M., Chitera, N., & Essien, A. (2009). Research on multilingualism in mathematics education in South Africa: 2000–2007. *African Journal of Research in Mathematics, Science and Technology Education*, *13*(sup 1), 65–80. https://doi.org/10.1080/10288457.2009.10740662

Setati, M., Molefe, T., & Langa, M. (2008). Using language as a transparent resource in the teaching and learning of mathematics in a Grade 11 multilingual classroom. *Pythagoras*, *67*, 14–25. https://doi.org/10.4102/pythagoras.v0i67.70

The Constitution of the Republic of South Africa. (1996). *Government Gazette*. (No. 17678). Retrieved from https://www.gov.za/sites/default/files/images/a108-96.pdf

The Interim Constitution of the Republic of South African. (1993). *Government Gazette*. (No. 15466). Retrieved from https://www.gov.za/documents/constitution/constitution-republic-south-africa-act-200-1993

Tobias, B. (2003). Do you speak mathematics? *Pythagoras*, *58*, 21–26.

Ubah, I., & Bansilal, S. (2019). The use of semiotic representations in reasoning about similar triangles in Euclidean geometry. *Pythagoras*, *40*(1), 1–10. https://doi.org/10.4102/pythagoras.v40i1.480

Uys, W.P. (1999). Afrikaans tweede taal sprekers (ATTS) en telwoorde. *Pythagoras*, *48*, 34–39.

Van Laren, L., & Goba, B. (2013). 'They say we are crèche teachers': Experiences of pre-service mathematics teachers taught through the medium of isiZulu. *Pythagoras*, *34*(1), 1–10. https://doi.org/10.4102/pythagoras.v34i1.216

Venkat, H., & Adler, J. (2012). Coherence and connections in teachers' mathematical discourses in instruction. *Pythagoras*, *33*(3), 1–8. https://doi.org/10.4102/pythagoras.v33i3.188

Vile, A. (1998). Developmental semiotics: Theory and practice. *Pythagoras*, *46/47*, 21–27.

Vorster, H. (2008). Investigating a scaffold to code-switching as strategy in multilingual classrooms. *Pythagoras*, *67*, 33–41. https://doi.org/10.4102/pythagoras.v0i67.72

Webb, L., & Webb, P. (2008). Introducing discussion into multilingual mathematics classrooms: An issue of code switching? *Pythagoras*, *67*, 26–32. https://doi.org/10.4102/pythagoras.v0i67.71

Zevenbergen, R. (2000). 'Cracking the code' of mathematics classrooms: School success as a function of linguistic, social and cultural background. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 201–223). London: Ablex Publishing.