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Research on Language and Multilingualism in Mathematics Education in Sub-Saharan Africa

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Abstract

The complexity of teaching and learning mathematics in contexts of language diversity has long been acknowledged. This study provides an overview of research that has been conducted in sub-Saharan Africa from 2010 to 2023 on language and multilingualism in the teaching and learning of mathematics. The surveyed research outputs were sourced from mathematics education and general education journals in Africa and top international mathematics education journals. Quantitative and qualitative analysis of these research outputs generated five conceptual themes, namely language as a tool used to create mathematical knowledge and understanding; the teachers'/students' proficiency in the language of learning and teaching; language policy and policy planning in African multilingual contexts; practices in multilingual mathematics classrooms (MMCs); and theory in researching language and communication in mathematics education. Among other findings, the study revealed where much research has been carried out in sub-Saharan Africa and highlights what education levels have been less focused on in research in mathematics education in multilingual classrooms. Drawing on Ruiz's (1984) orientation to language, the corpus of literature revealed overall awareness of language as a resource and among its recommendations, the article argues for the operationalisation of the concept of language-as-resource that lends to content and context specific practices such as translanguaging in multilingual mathematics classrooms in sub-Saharan African.

Keywords: code-switching; language practices; language proficiency; multilingualism; translanguaging

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Introduction

With an estimate of over 2000 languages in Africa (Mazrui and Mazrui 1998) of which most are in sub-Saharan Africa (SSA), it will come as no surprise to think of SSA as the epicentre of the biblical tower of Babel. As such, it also comes as no surprise that most classrooms in SSA are multilingual. However, beyond the issue of multilingualism in sub-Sahara African classrooms is the fact that the language of teaching, learning, and assessment is not the first or home language for a majority of students who do mathematics. Research has long acknowledged the complexity of teaching and learning mathematics in such linguistically diverse contexts (see Adler 2001; Barwell 2009, 2018). In fact, over the years, research has come to acknowledge the intricate relationship between language and mathematics, and between multilingualism and the teaching and learning of mathematics. In terms of the former, that is, language and mathematics, Durkin (1991) argues that mathematics begins in language, progresses or advances through language, but also stumbles in language. There is a general admission that mathematics is itself a language, albeit a specialised language (Pimm 1991) as it takes on an ordinary language to give it meaning. What this means is that the teaching and learning of mathematics is dependent on some level of proficiency in the language in which the mathematics is imbedded because the different tasks associated with teaching and learning of mathematics, such as solving problems, explaining, and assessments, are heavily language dependent (Essien 2018). In terms of the latter, that is, multilingual issues in mathematics teaching and learning, Barwell (2009) argues that where the language of learning and teaching (LoLT) is English, those who are English first language speakers are already familiar with the structure of English. This is not the case for those whose LoLT is not their home language. While first language English speakers need to contend with learning the structure of the mathematics language, those with English as a second language need to contend with not only learning the structure of the mathematics language but also the structure of the LoLT—the language in which the mathematics itself is embedded. This added complexity of teaching and learning in contexts of language diversity is made more complex when students come to class with varying proficiencies in both their home languages and the LoLT.

As indicated elsewhere (see Phakeng and Essien 2016), while Pimm's (1981, 1987) seminal work on language and mathematics opened the door to research on language issues in the teaching and learning of mathematics, it was Adler's (1995) work on multilingualism in the mathematics classrooms in the specific African context of South Africa that became the pioneering work in this field. Since then, there has been a rise in research on language and multilingual issues in the teaching and learning of mathematics in different linguistic contexts in Africa and globally. While in Africa there has been specific country landscape reviews of research in the field, there has, thus far, been no review research taking stock of the research on language/multilingual issues in the teaching and learning of mathematics in SSA. The purpose of this study was thus to provide an overview of research that has been conducted on both language and multilingual issues in the teaching and learning of mathematics in the last approximately

15 years. We aimed to investigate literature which has been the focus of research in language/multilingual issues in the teaching and learning of mathematics, and to determine where future research needs to focus. Our review article is informed by the following guiding questions:

- What is the current state of research on language/multilingualism in the teaching and learning of mathematics at all levels of schooling in SSA?

- What does this research reveal about the teaching and learning of mathematics in multilingual classrooms in SSA? What gaps exist?

To provide answers to these questions, we examined research articles published in mathematics education and general education journals in SSA, and top international mathematics education journals (see Williams and Leatham 2017). We provide more discussions on the inclusion criteria in the methodology section.

Ruiz's Orientations to Language

Ruiz's (1984) seminal work on language orientations highlights three significant orientations towards language: language-as-problem, language-as-right, and language-as-resource. The language-as-problem orientation accentuates the regular utilisation of only one language and an inclination to use the more powerful language (McLachlan and Essien 2022). This type of orientation thus perceives multilingualism as a problem that should be fixed (Planas and Setati-Phakeng 2014; Ruiz 1984). In most sub-Saharan African contexts where politics often influences teaching and learning in schools, this orientation often means the use of a colonial language as the only preferred language owing to the status of the language (Setati 2008). On the other hand, the language-as-right orientation advocates the individual's right to express themselves in their own language without being discriminated against (McLachlan and Essien 2022). However, this orientation becomes impractical particularly in contexts where political interferences are inevitable. Typical examples of such contexts are described by Planas and Setati-Phakeng (2014) in South Africa and in Catalonia-Spain, where despite the presence of more than one language, a monolingual orientation that privileges one language above other languages is entrenched in the school systems. The language-as-right orientation is made even more impractical by the view held by many teachers and learners who are positioned by the social and economic power of the colonial language, thus considering it as the only language that can provide them with access to social goods (Setati 2008).

The language-as-resource orientation regards the use of multiple languages as beneficial and sees the epistemic potential of the multiplicity of languages as something that should be harnessed (Ruiz 1984). As such, it regards multilingualism as a resource and not a problem that must be resolved (Barwell 2018). According to this orientation, multilingualism serves as a resource for all learners regardless of whether the LoLT is

their first language or an additional language. This orientation thus calls for prestige to be placed on all the languages as imperative resources for teaching and learning, thus making it possible for them to coexist. Elaborating on these orientations, McLachlan and Essien (2022) argue that these three orientations are useful in thinking about language issues in teaching and learning, in developing language policies, and in offering insights into how policy and language practices may be enlightened. In this review article, Ruiz's (1984) language orientation framework is used to engage with the orientation to language evident in the body of literature under scrutiny as this provides insights into how language is perceived in the body of literature in SSA.

Methodological Approach

Using Google Scholar and African Journals Online (AJOL), we searched both mathematics education journals and general education journals in SSA. For international journals, we focused specifically on mathematics education journals, using the list of the top 20 mathematics education journals by Williams and Leatham (2017). Three key criteria were used as inclusion criteria for research outputs in this review:

(1) The context in which the research output is imbedded is the teaching or learning of mathematics in SSA.
(2) The research output is focused on language/multilingualism in the teaching and learning of mathematics.
(3) The research output was published between 2010 and 2023.

The geographical location of the publishing author(s) of the article was not a deciding criterion for exclusion. If a research output satisfied all three of the above criteria, it was included in the corpus of literature for this review. Figure 1 shows the article selection process that we followed.

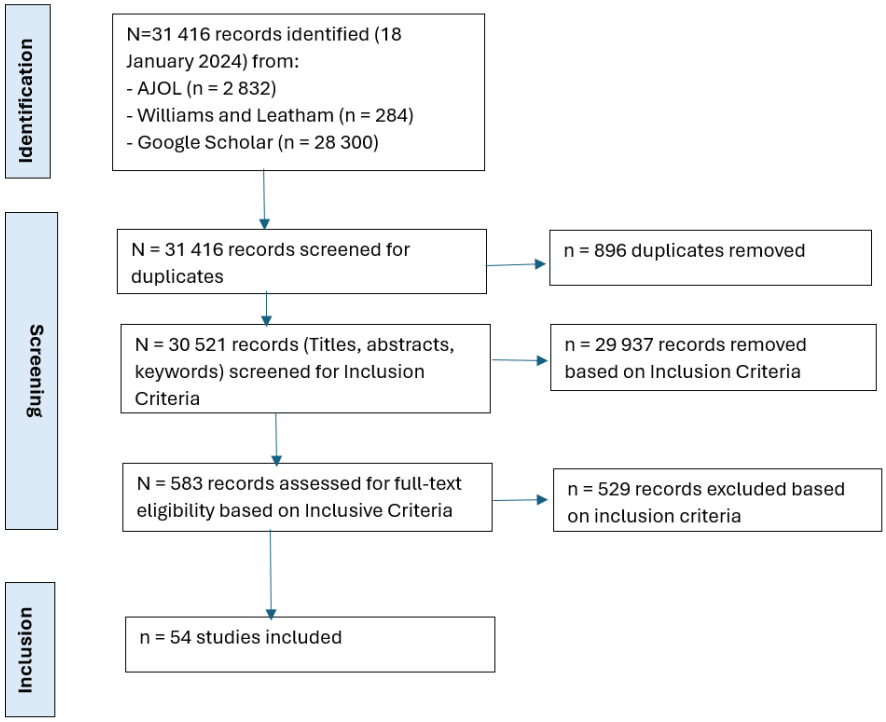

Figure 1: Article selection process

Book chapters and predatory journals were not included in our search. We used key words ("language and mathematics," "multilingual(ism) and mathematics," "discourse in mathematics," "language and communication," and "mathematics in mother tongue") to search Google Scholar, African Journals Online (AJOL), which houses the largest collection of African-published scholarly journals, and Williams and Leatham (2017). As shown in Figure 1, a total of 54 articles were identified for this review.

General Overview of Reviewed Literature

Figure 2 highlights the number of publications per year for the included corpus of articles within the review timeframe:

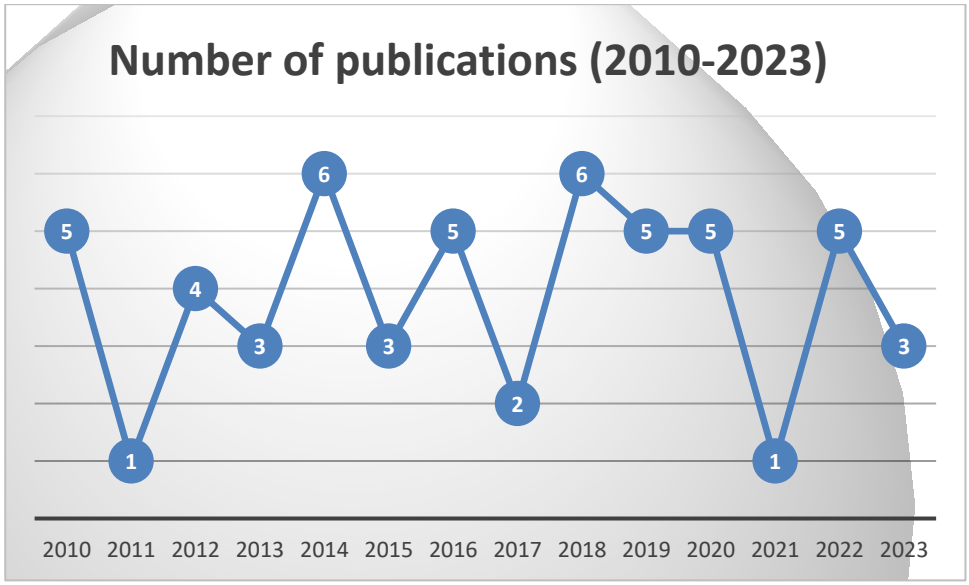

Figure 2: Accumulated number of publications per year (n = 54)

Figure 2 presents an erratic picture of the number of articles per year that focused on language and multilingual issues in the teaching and learning of mathematics. There was no evident growth in publications focusing on language/multilingualism in mathematics in the last four years of the survey period. Two limitations of our literature survey are the fact that book chapters were not part of the corpus of literature surveyed, and that only articles published in English were considered, thereby excluding research outputs in other languages.

Table 1 provides a more global picture of literature in SSA in the field of language/multilingualism in mathematics.

Table 1: Location of research per country

Country	Total	African journals	International journals	Research type				Level			
				Qualitative	Quantitative	Mixed	Conceptual	Primary	Secondary	Teacher education	Inservice
Botswana	1	1		1						1	
Kenya	2	2			1		1	1	1		
Malawi	4	2	2	2	1			2	1	1	
Mauritius	1		1	1					1		

Namibia	1	1		1				1			
South Africa	44	34	10	21	7	4	1	22	9	6	1
Eswatini	1	1		1						1	
Zimbabwe	2	2		1	1			2			
Total	**56**	**43**	**13**	**28**	**10**	**4**	**2**	**28**	**12**	**9**	**1**

Note. **Total number is more than articles reviewed owing to dual/multiple coding.

A number of findings are evident from Table 1. First, most of the publications (about 79%) are from South Africa. This is clear evidence that more attention is being paid to language and multilingual issues in the teaching and learning of mathematics in South Africa than in other parts of Africa. One explanation for this lies in the fact that the pioneering work that was done on multilingualism and the intricacies of teaching and learning in multilingual classrooms started in South Africa with the work of Adler and Setati (Adler 2001; Setati and Adler 2000). But the reality is that most other SSA countries are more linguistically diverse than South Africa, and the nature of multilingualism varies across different linguistic settings in SSA (Essien et al. 2024). As such, these countries will benefit from research that focuses on the intricacies of teaching and learning of mathematics that is particular to their context given their specific nature of multilingualism.

Second, most of the papers are in African journals (about 77%). There is a need for more international presence on issues pertaining to language/multilingualism and mathematics and on what other continents can learn from the particularities of teaching mathematics in a linguistically diverse context that characterises SSA. The table also shows that more work has been done at the primary level than other levels and largely in South Africa. Language and multilingual issues in the teaching of mathematics at teacher education level is still the least researched area. Also, as in the systematic reviews by Setati et al. (2009) and Essien (2018), there is still a limited number of quantitative and mixed method studies on language and multilingualism in mathematics, and even fewer conceptual studies.

Conceptual Themes That Emerged from the Corpus of Literature

Two levels of iterative processes—inductive and deductive approaches—were used in our attempt to organise the reviewed articles into themes. Ruiz's (1984) orientation to language framework provided an overarching lens from which we first coded the papers. This first level of coding dealt with whether the article's orientation was towards language-as-problem, language-as-right, or language-as-resource as defined by Ruiz. The second level of coding—the inductive process—entailed reading through all the surveyed articles, identifying their key focus, and then mapping them to Ruiz's three orientations to language. The results from this inductive process resulted in the

emergence of five themes which are elaborated on in Table 2. We individually coded all the articles into these themes and then met to compare our coding. We then refined our coding of each paper after reaching a consensus.

Table 2: Emergent conceptual themes from the surveyed research outputs

Theme	Key Focus
Language as a tool used to create mathematical knowledge and understanding	Focus on ways in which language is used in the mathematics classroom to construct knowledge/meaning and to regulate access to that knowledge.
The teachers'/students' proficiency in the language of learning and teaching	Focus on the interrelationship between proficiency in language and mathematics, and how proficiency in language is related (or not) to proficiency in mathematics. Also focus on how linguistic difficulties impact on student performance. Here, we included only articles where there was no actual implementation/use of more than one language in the teaching and learning of mathematics.
Language policy and policy planning in African multilingual contexts	Focus on debates on language policies and their role in the teaching and learning of mathematics.
Language practices in multilingual mathematics classrooms	Focus on specific mathematical practices that are used in the teaching and learning of mathematics in African multilingual classrooms. Here, in terms of the use of more than one language as a practice, we included articles where there was actual use of two or more languages in mathematics teaching and learning. If the article theorised on a particular practice, it was coded as Theme 5.
Theory in researching language and multilingualism in mathematics education	Focus on what theories are relevant to doing research on multilingualism in African multilingual contexts; Focus on the challenges and opportunities that arise from working with theories from mathematics education and other disciplines.

Research outputs were coded according to the themes they aligned with the most. Some articles focused on more than one theme and were thus coded multiple times. It is important, therefore, to note that the total number of articles in Figure 3 is not equivalent to the total number of research outputs that were analysed.

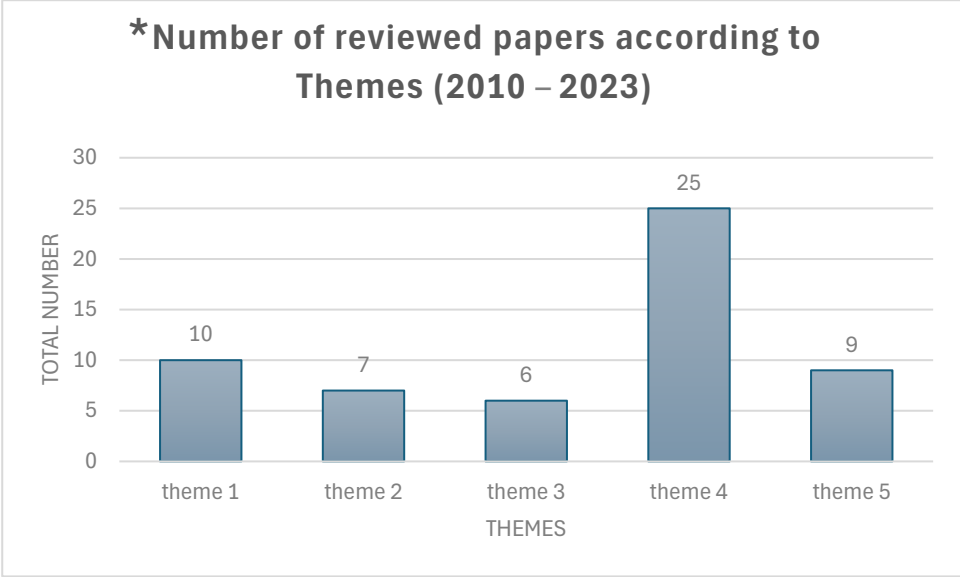

Figure 3: Surveyed articles according to themes (*n = 57 because of dual/multiple coding of some papers)

The graph in Figure 3 shows that the theme that received the most attention was Theme 4 on language practices in multilingual classrooms. In what follows, we provide an in-depth analysis of the reviewed literature in each of the themes. We bring the language orientation framework to bear on these themes in our analysis.

Thematic Analysis

Theme 1: Language as a Tool Used to Create Mathematical Knowledge and Understanding

Research on language use in the teaching and learning of mathematics highlights the pivotal role of language as a tool to create mathematical knowledge and facilitate understanding (Barwell 2018; Moleko 2018; Morgan et al. 2014). The 10 articles (one from Kenya and nine from South Africa) published in SSA in the last 14 years in our corpus under this theme emphasised the importance of language as a tool to facilitate understanding and to create mathematical knowledge.

In the Kenyan study, which focused on the relationship between mathematical language and verbal language, K'Odhiambo and Gunga (2010) argued that the teaching of mathematics should to some degree involve the teaching of certain linguistic patterns. The authors further argued that if mathematics is a language, then the linguistic meanings which it embodies must be known as well as what the consequence of such conceptions can be regarding the development of a solid foundation for mathematics, and for the improvement of mathematical pedagogy. Since mathematical language is

expressed in a mathematics register, K'Odhiambo and Gunga (2010) recommended that the Mathematics Problem Solving Strategy be regarded as a form of dialogical tool for undertaking mathematical problems.

Two studies from the corpus of literature under this theme focused on pre-service teacher education. Both studies attributed poor performance in mathematics and a lack of mathematical knowledge and understanding in South Africa to the pre-service mathematics teachers' poor command of the language of learning and teaching. Both studies thus argued for the "teaching of exact mathematical language to pre-service mathematics teachers in initial teacher education programmes" to prepare and empower them for their future careers as proficient mathematics teachers (Van Jaarsveld 2016, 164; Van Jaarsveld 2018).

Under this theme, six other studies from the corpus of literature focused on language issues in multilingual classrooms. To address the language problems in this context, the study by Mostert and Roberts (2020), Stander et al. (2022), Coetzer et al. (2023), Bezuidenhout (2022), and Lampen (2015) revealed the need for teachers/lecturers/learners to be aware of the way they use language to express mathematical ideas or processes and to ensure that these ideas/processes are explicit to reduce confusion. Fleisch and Schöer's (2014) study in South Africa revealed the usefulness of an intervention programme which sought to use multilingual resource packs and coaches to support the teaching and learning of mathematics in multilingual classrooms.

Although all the studies published under this theme, including the article by McLachlan and Essien (2022), describe the role of language as a tool used to create mathematical knowledge and understanding and generally espouse the language-as-a-resource orientation, we found no study that investigates ways of or provides a framework for strengthening teachers' use of language in MMCs.

Theme 2: The Teachers'/Students' Proficiency in the Language of Learning and Teaching

Research linked to teachers'/students' proficiency in the language of teaching and learning has always been associated with concerns over whether or not bilingualism/multilingualism is positioned as an advantage rather than as a problem (Barwell 2009). This is more so in SSA where, more often than not, the LoLT is not the first language of both teachers and students. In this regard, the pioneering work of Cummins (1979) in postulating the threshold theory, the empirical work of Dawe (1983), and the work by Clarkson (1992) are to be noted. In these pioneering works, there is agreement that proficiency in both the LoLT and the home language of students is an important index in developing proficiency in mathematics. In recent times, research has come to focus on bilingualism/multilingualism as a resource in the teaching and learning of mathematics (Planas and Setati-Phakeng 2014; Sapire and Essien 2021). The six articles (all from South Africa) under this theme published in SSA in the 14

years covered by our corpus all focused on language proficiency in the teaching and learning of mathematics, and as such on language-as-a-resource in mathematics teaching and learning. While Sibanda and Graven (2018) focused on the influence of English reading and comprehension on mathematics attainment, Sibanda (2017) focused on grade 4 students' linguistic difficulties in engaging with mathematics tasks; and Essien's (2010a) experimental study investigated whether and how improvement of students' English language proficiency enables or constrains the development of mathematical proficiency. These studies revealed the intricate link between mathematics proficiency and performance in mathematics. Van Jaarsveld's (2018) study explored the quality of vocabulary used by pre-service teachers when doing mathematics. The absence of and the inexact use of mathematics vocabulary in pre-service teachers' written meta-narratives prompted the key recommendation for the need for mathematical vocabulary (and language) to be a teaching focus when considering teachers' preparedness for teaching mathematics. This finding relates directly to Tshuma and Le Cordeur (2019) who investigated teachers' language proficiency in the language of teaching and learning (English) and found teachers' language proficiency to be low resulting in the likelihood of compromised mathematics teaching.

Some of the above studies focused on the effects of interventions to improve teachers' and students' English proficiency in order to improve mathematics performance. What is surprising is the limited number of studies on the relationship between linguistic proficiency and performance in mathematics when mathematics is taught in the mother tongue. A study that goes beyond simply looking at the English language proficiency vis-à-vis the mathematics proficiency of students is the study by Makgamatha et al. (2013), a quantitative study on the language and mathematics skills of 75 000 grade 8 students in South Africa. In addition to showing the positive correlation between the participants' English language test scores and mathematics test scores, this study also investigated testing students' abilities in mathematics when the language of testing is in their home language and found an even more positive correlation. It is also somewhat surprising that in our timeframe, only one article (Makgamatha et al. 2013) in our corpus of literature under this theme focused on home language use in relation to mathematics attainment and none focused specifically on proficiency in home language in relation to mathematics performance even though early literature in this field acknowledges the cognitive benefits that accrue to the development of and proficiency in students' home language.

Theme 3: Language Policy and Policy Planning in African Multilingual Contexts

Trudell and Piper (2014, 5) define language in education policy as "a set of principles formulated and legally established by the state, intended to guide language use particularly in the public domain." In a continent like Africa where many indigenous languages coexist alongside European languages, the need for a coherent language in education policy is not only a necessity but an instrument for enabling the recognition

of African languages, thus empowering and enabling the use of African languages as a resource. Language in education policies are also a tool for enabling equity in MMCs.

Of the 54 articles included in this scoping review, only six had an overarching research purpose related to language policies (and planning) and their role in the teaching and learning of mathematics. Chitera (2011, 2012), Shuukwanyama et al. (2022), and van Laren and Goba (2013) all focus on the alignment between the language policy of Malawi and South Africa and teacher preparation aimed at implementing this policy. Chitera's (2011, 2012) studies found that not much is done in teacher education to prepare teachers to use the indigenous languages to teach in the early grades even though the language in education policy stipulates that the early grades are to be taught in the indigenous language. Van Laren and Goba (2013) take up this policy–practice mismatch by examining one case where pre-service teachers were taught in the indigenous language they would use as the LoLT after their qualification. They noted some of the challenges (expressed by the pre-service teachers) in the use of an indigenous language as the LoLT in their teacher education programme. Some of these challenges relate to the use of the indigenous language for academic concept explanations; the mathematics register in the indigenous language; and the status of the language (also see Nyika 2015). Some of these challenges are also captured in Essien (2018) whose study found that the implementation of the language in education policies in Malawi, Kenya, and South Africa is fraught with difficulties, notably because a lot more still needs to be done to develop the indigenous languages as languages of scholarship.

Planas and Setati-Phakeng (2014) draw on the work of Ruiz (1984) on the three perspectives on language—language-as-right, language-as-resource, and language-as-problem—to argue that giving priority to the perspective of language-as-resource rather than the other two perspectives in language policies in South Africa (and in Catalonia) will enable the reduction of "some of the unequal conditions of learning mathematics in multilingual classrooms" (Planas and Setati-Phakeng 2014, 884). By so doing and like the other publications under this theme, Planas and Setati-Phakeng espouse the language-as-resource orientation to mathematics. Based on this orientation, this article pushes for language in education policies to advocate for the use of students' home languages together with the language of instruction to make mathematical content more accessible.

What is apparent in the five articles which focus on language in education policy is the need for research to contribute to the existing language policies so that these policies contribute to cognitive development and inclusion in MMCs. It is interesting to note that unlike in earlier decades (see, for example, Heugh 2008), there are no research studies focusing on providing empirical data to inform policy on the duration of home language instruction before a switch to the so-called world language is implemented. We will engage further with this in the concluding section.

Theme 4: Language Practices in MMCs

The articles under Theme 4 focus on various practices used in MMCs; as such, they focus on language as a resource in mathematics teaching and learning. Six practices were identified: code-switching; exploratory mathematics talk, visual multilingual mathematics student companion, translanguaging, the use of technology, and the use of two languages. Twenty-five articles with the above focus were identified from the literature, with most of these practices being implemented in the South African context. Twelve of these articles focus on code-switching, one on exploratory mathematics talk, one on using multilingual visual explanatory mathematics student companion, two on translanguaging, one on using technology, and six on the parallel use of two languages in mathematics classrooms. Two did not fall into any of the categories above.

Code-Switching

Code-switching is defined as the use of two or more languages in the same talk (Adler 2001). In the Zimbabwean context, the use of code-switching was encouraged to facilitate students' comprehension of the mathematical concepts, to develop students' interest in mathematics, and to "break classroom tension" (Chikodzi and Kaino 2020). In Mauritius, on the other hand, a call was made for teacher education programmes to explicitly consider code-switching, so that the mathematics pre-service teachers could be well informed about the possible benefits and dilemmas of this practice (Salehmohamed and Rowland 2013). To ensure the smooth implementation of the practice in general, Chikiwa and Schafer (2016) emphasise the need for "consensual understanding" of the best practices for code-switching to promote code-switching that is "precise, consistent, transparent and thus supportive of teaching for conceptual understanding of mathematics in secondary schools" (Chikiwa and Schafer 2016, 244).

Although research shows that code-switching is prominently used to bridge communication gaps and to assist students access mathematics, especially in multilingual classrooms, scholars share different perspectives regarding its implementation. For instance, despite being appreciative of code-switching as a useful strategy to facilitate learning in MMCs, Essien (2010b) holds the view that sometimes the intentional use of English is necessary to enculturate the pre-service teachers into becoming proficient users of the LoLT (English in this case). Drawing from the field of developmental psycholinguistics and also from the conceptual development theory, Henning (2012, 75) cautions against the excessive use of code-switching practice as it has the potential to pose serious challenges particularly when "young children" are "still navigating their way into the abstract world of school learning, using language to map their cognitive, academic platforms for learning." According to Maluleke (2019), although code-switching serves as an "empowerment strategy" for students with limited proficiency in the language of learning and teaching, the teachers' responsibility remains to ensure that students use the mathematical language in a manner that gets them accustomed to the applicable discourse. Robertson and Graven (2020) argue that it is imperative for teachers to maintain the right balance between "inclusivity" and

"access" when using code-switching. These authors further caution that without the right balance (e.g., focus being placed on "inclusivity" more than "access" and vice versa), the possibility is that students' opportunities for practising the use of English may be reduced and this may subsequently impede their "access" to English which is regarded as the global language. They thus recommend careful use of code-switching, particularly when dealing with word problems since these problems are aligned to specific forms of "mathematical language" that are not easily translatable into other home languages. Similarly, in their study where the focus was on the use of code-switching to promote learning for immigrant students, Mahofa et al. (2018, 27) recommend the use of "mixed language groupings" and "explicit mathematical terminology definitions." They also recommended that the teachers should minimise the use of code-switching to give students opportunities to learn and be proficient in the language of learning and teaching. Even though the use of code-switching is encouraged by various scholars and educators, a study by Kasule and Mapolelo (2013) indicates that some teachers still prefer not to use this practice and thus teach mathematics exclusively in English. This calls for some reforms in teacher education to empower the prospective teachers to adapt their teaching practices to the students' language backgrounds. In line with this, Mulaudzi (2016) suggested the implementation of intervention strategies by the South African Department of Education to adequately train the foundation phase teachers so they could learn the "differentiated official languages" that are often represented in a particular classroom to support the English language learners.

Translanguaging

García (2009, 45) defines translanguaging as the "multiple discursive practices in which bilinguals engage in order to make sense of their bilingual worlds." The two studies from our corpus of literature highlighted the positive effects of translanguaging in facilitating learning in MMCs. Tyler (2016) portrays the shifts between discourses which were observed in the study, which occurred in a "multidirectional way." This form of practice (translanguaging) was found to be beneficial as it provided students with opportunities to establish the connections between mathematics registers and enabled them to develop the "receptive ability" in the new mathematics English register. The study calls for some reform in teacher education, particularly in the way the mathematics pre-service teachers are trained, and argues for emphasis to be placed on developing the pre-service teachers' "translanguaging competencies" which are fitting to their classroom's specific linguistic environment while developing their comprehension on how to use a variety of students' "linguistic resources." Makoye's (2019) study, which was conducted in Zimbabwe, in which translanguaging was used as a "pedagogical resource," revealed a significant difference between the performance of the students who used translanguaging and those who used the LoLT only. Students who used translanguaging developed a strong mathematics register for "area and perimeter" mathematical concepts.

The Use of Two Languages to Teach Mathematics

Six studies in our corpus of literature, five from South Africa and one from Malawi, revealed the significance of deliberately planning for and using two languages in an MMC to provide epistemic access. More specifically, while Mpalami (2022) cautions against the translation of certain mathematics register into an African language, Schäfer (2010) found that the translation of the mathematical concepts into two indigenous games provided both the students and the teachers with epistemic access and based on this, the author argues for the development of the mathematical concepts into two indigenous languages. Following on from this, Koch (2015) sought to reveal the contribution that the bilingual testing could make to a radical new way of approaching language in education in the context of South Africa. Fleisch and Schöer's (2014) study revealed the significant use of the learning intervention which was built on ideas developed from the earlier generated policies (e.g., lesson plans in the Foundations for Learning Campaign) to mediate learning. Although the intervention had positive effects, the study shows that no definitive deductions could be drawn about its effectiveness. Mostert (2020) highlighted the use of the two languages to teach mathematics as important in aiding the understanding of the early grade students to solve the problems. This study, and that of Kazima et al. (2023) on the concept of zero, stress the significance of "understanding the ways in which African languages express mathematical ideas in order to identify and leverage affordances for teaching and learning mathematics" (Mostert 2020, 1)

Other Practices

Robertson and Graven's (2018) study, which was guided by the socio-linguistic theory, demonstrated the usefulness of the "exploratory mathematics talk" using a second language. The practice was found to be useful in helping students "make mathematical meaning in a subtractive bilingualism" background. In an attempt to address the many complex linguistic diversity issues in South African MMCs, Botes and Mji (2010) introduced the "visual multilingual mathematics student companion" as an "aid" to assist the mathematics students to relate mathematical terms and concepts in English with terms in their own languages. The findings of their study revealed the usefulness of the student companion in terms of facilitating student understanding of the mathematical vocabulary and subsequently improving the marks of the second language speakers. Another study conducted in South Africa revealed the practice of using mobile technologies in addressing the learning and teaching challenges in linguistically diverse contexts (Jantjies and Joy 2016). The results of this study revealed the vital roles which language and culture play in the identification of the technologies needed to support learning and teaching in such settings.

In terms of orientation towards language, there is an orientation towards language-as-resource in all the papers under this theme. We will engage with some gaps under this theme in the discussion section.

Theme 5: Theory in Researching Language and Multilingualism in Mathematics Education

As indicated previously, the corpus of articles under Theme 5 deals with literature on which theories are relevant to doing research on multilingualism in mathematics classrooms in the context of Africa. We also considered articles that deal with the challenges and opportunities that arise from working with particular frameworks or theories given the nature of multilingualism in different SSA settings. Only nine articles with the above focus were found, all from South Africa, and all with an inclination towards the language-as-resource orientation. The theoretical article by Robertson and Graven (2019) explored how language can be used as a tool to either include or exclude certain groups of students from genuine opportunities for mathematical sense-making. Drawing on language immersion education models, they argue for the necessity to provide students with opportunities for becoming bilingual and biliterate. This need for systematic support for students' (second) language development also runs through Robertson and Graven (2020). The work of Henning (2012) draws on post-Piagetian and neo-Vygotskian theories regarding the interplay between cognitive development and language to argue for a linguistically stable pedagogy where there is no excessive code-switching as this could lead to student under-preparedness for written language and learning in general.

Ledibane et al.'s (2018) theoretical piece, and Essien (2021) attempted to integrate or merge different theories related to the teaching and learning of mathematics in relation to language. They argue that the resultant theoretical model enables teachers to teach both mathematics and English simultaneously to students who are still acquiring proficiency in the language of teaching and learning.

Van Jaarsveld's (2016) grounded approach work uses the Vygotskian perspective on thought and language, the Habermasian ethical and moral communicative action, and the Freirian emancipatory critical consciousness to argue for the necessity for the use of exact (authentic) mathematical language in teacher education. Using Wenger's communities of practice theory, Essien (2014), whose work also focuses on teacher education, explores the multifarious dimensions in teacher education and how classroom practice in teacher education classrooms can contribute to the enculturation of pre-service teachers into five interacting identities in teaching education. Finally, Trouche et al. (2023) propose three approaches regarding resources in the professional activities of mathematics teachers. These approaches emerged concurrently in distinct countries, each characterised by unique linguistic, curricular, and social contexts.

In all nine articles under this theme, it is noteworthy that many of the theories are drawn from disciplines other than mathematics. This is not surprising given that the relationship between language and mathematics is by its nature interdisciplinary. In terms of orientation, the articles under this theme underscore the significant role of language as a resource in facilitating communication, engagement, and understanding in the mathematics learning process. Based on the proposed theories, the articles in this

theme stress that viewing language as a resource is crucial for fostering meaningful learning in multilingual classrooms.

Closing Remarks and Directions for Future Research

Unlike the "language as problem" orientation, which views multilingualism as a barrier, the "language as resource" perspective sees multilingualism as a strength and a powerful tool for meaningful mathematics learning, especially in multilingual classrooms. It is indeed important to observe that many of the articles in our corpus of literature espouse the language as resource orientation. This is a clear indication that the debate on the teaching and learning of mathematics in SSA has moved away from the dichotomies that ask the question as to which language is best used to teach mathematics. Rather, the recognition of the use of multiple languages, and the quest for how to draw on the epistemic potential of multiple languages in multilingual mathematic classrooms in SSA have started to dominate discourse on mathematics education.

In addition to gaps already identified, a key gap from the corpus of literature surveyed in this article is that of research that focuses on mathematics discourse and the discourse of mathematics, specifically, student engagement and social interaction in mathematics classrooms. This has been a focus of research pre-2010 (see Adler 2001; Setati and Adler 2000). There is no reason to think that the importance and relevance of such research in SSA is no more critical for the teaching and learning of mathematics. Moreover, such research that deals with productive disciplinary engagement has, in recent times, gained more traction in other parts of the world (see, for example, Erath et al. 2021; Moschkovich and Zahner 2018).

Also, much of the corpus of literature is on practices and more specifically code-switching. What remains to be done in terms of practices is research on other important discourse practices (e.g., revoicing, translanguaging) and how these practices may enable not only productive disciplinary engagement, but also how they can become a window to better attainment of mathematical conceptual understanding (Erath et al. 2021). Additionally, research on discourse practices (that work) of teachers who do not share the same home language as most of their students is important in SSA where this phenomenon is a common occurrence.

Furthermore, our findings also suggest the need for more research on home language use in the teaching and learning of mathematics. More studies that provide empirical evidence to support the (approximate) appropriate duration for studying in an African indigenous language as the LoLT before transitioning to a "world" language (English, French, and Portuguese) are particularly needed to inform policy. This is particularly important given that in a country like South Africa, there are talks about moving the language transition class from grades 4 to 7 through an incremental introduction of English. Such a move needs to be informed by research rather than political expediency. A similar case is noted in Malawi which has recently switched to the "straight-for-

English" approach, in which right from grade 1 students learn in English rather than their home language.

What also remains to be done is research that deals with the cultural dimensions in the teaching and learning of mathematics. Given the fact that Africa is rich in culture and cultural diversity, it is somewhat surprising that this area has not been a focus in the corpus of literature we surveyed. Related to this is the necessity for more research on norms of practice that foster epistemic access to mathematics and the development of a joint sense of responsibility in the co-construction of mathematical knowledge. The idea is not for a one-size-fits-all adoption of norms across SSA. The particularities of individual contexts and the nature of multilingualism in different contexts are important indices in determining productive norms that have the potential to lead to constructive discourse engagement (Essien 2020). These particularities of the different individual contexts within/across countries and the distinct nature of multilingualism in these different contexts can become a research asset from which lessons can be drawn in our quest for a more effective way to teach mathematics in SSA.

In conclusion, in terms of Ruiz's orientation, while research in SSA generally views language as a resource, we argue that this concept needs to be further operationalised for meaning making purposes in MMCs so that it attends to the complex nature of multilingualism across different linguistic contexts in SSA. Such an understanding of language-as-resource for meaning making in MMCs entails a good understanding of the discourse practices needed in a particular linguistic context and appropriate to a particular mathematics content. Consider the practice of translanguaging, for example: What makes for a "good" translanguaging practice? Or code-switching or revoicing: What makes for a good code-switching/revoicing practice? Research and developmental work in SSA need to focus on these going forward bearing in mind the complex nature of multilingualism (see Essien et al. 2024) in SSA.

In summary, while the "language as resource" approach is beneficial, its implementation requires careful planning and sensitivity to the classroom's linguistic dynamics. Mathematics teachers must therefore be able to balance the use of multiple languages with the epistemic dimension of language to ensure that all students have access to the mathematical content.

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