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Anthony Essien; Jill Adler

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ORIGINAL PAPER

Language in mathematics education in Africa: chronicling recent growth and leadership in the field

Anthony A. Essien[1] · **Jill Adler**[1]

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Abstract
This paper is a systematic review of literature on research in mathematics education in multilingual classrooms in Africa where, across most countries, the majority language is not the language of teaching and learning. The surveyed research outputs span from 2015 to 2024, and were sourced from mathematics education and general education journals in Africa, book chapters, and top international journals. We used Google Scholar and the African Journals Online (AJOL) platforms to search for publications. A total of 75 publications met our inclusion criteria. We use four orientations – to language, to knowledge, to mathematics teacher education, and to classroom teaching – (which emanated from a dual process of induction and deduction) to understand our corpus of literature. Quantitative and qualitative analyses of these research outputs show, among other findings, that the vast majority of the 75 papers, reflect a heteroglossic orientation to language, and thus a view that multiple languages in use - language plurality - matters in multilingual mathematics education. A second key finding is that a focus on the integration of language and content learning goals was far greater in school classroom contexts as compared with mathematics teacher education contexts. There is further evidence that reflects an orientation to knowledge growth – the epistemic - and concern with how languages in use support functional multilingualism.

Keywords Multilingualism · Monoglossic · Heteroglossic · Functional multilingualism · Translanguaging · Language ideology

1 Introduction

With a total of 54 countries and more than 2000 spoken languages (Mazrui & Mazrui, 1998), it can be argued that a distinguishing feature of the African continent lies in the fact that it has one of the highest linguistic diversities in the world. In such a context, multilingual classrooms are, and have been, a norm rather than an exception. Research on teaching and learning (TL) mathematics has shown that teaching mathematics in contexts of language diversity presents both challenges and opportunities (e.g Essien, 2018; Essien & Moleko, 2025; Feza et al., 2022; Barwell et al., 2016), and in recent years, this research has positioned multilingualism as a resource and an advantage rather than as a problem or a deficit (Robertson & Graven, 2018, 2019; Adler & Essien, 2024; Maluleke, 2019; Mostert & Roberts, 2022; Poo & Venkat, 2021). This position – of the epistemic potential of the multiplicity of languages in classrooms – has gained traction post the early 1970s and contrasts with earlier studies where researchers concluded that due to the dissipation of stock of available intellect resulting from knowing more than one language, bi/multilingualism has a negative cognitive effect (see for example, Macnamara, 1977). Following a UNESCO Symposium (1974) on "Interactions between linguistics and mathematical education" came two strands of work in mathematics education. The first strand focused on providing empirical evidence that could inform the debate on whether the use of learners' own language impeded or enhanced their mathematical understanding (See Clarkson, 1992; Dawe, 1983). The second strand of work was focused on the relationship between language and mathematics where the seminal work by Pimm (1981, 1987), and Durkin and Shire (1991) on the interrelationship between language and mathematics opened doors for more research focused on language issues in the teaching and learning of mathematics.

Perhaps, Austin and Howson's (1979) work, which engaged with issues in the teaching and learning of mathematics in bi/multilingual environments using specific examples

✉ A.A. Essien

[1] University of the Witwatersrand, Johannesburg, South Africa

drawn from different linguistic contexts (and drawing on earlier research), was the first to cast a spotlight on children who learn mathematics in a language that is not their home language. Subsequent to this, Dawe (1983) and Clarkson (1991, 1992) investigated the links between language proficiency and mathematics attainment, and Adetula (1990) in Nigeria explored word problems in English and in the home language (without explicit attention to multilingualism). As Phakeng and Essien (2016) note, in all the above work, a focus on multilingualism and the intricacies of teaching and learning of mathematics in multilingual classrooms were out of view. Adler's (1995, 2001) work in Africa was the pioneering work in this field of multilingualism in mathematics classrooms in the specific African context of South Africa. Hence, it can be argued that research in Africa on multilingualism in the teaching and learning of mathematics in situations where the language of learning and teaching (LoLT) is not the majority language was pioneering research in the field (see also Barwell, 2024). It sparked and undergirded the extensive growth of this field over now nearly three decades. As Planas and Pimm (2024) note in their review paper on language and communication in mathematics education, research on multilingual mathematics classrooms has become stronger and more present than ever, opening the question of what this growth has been over the years within Africa.

This paper provides a systematic review on the growth of research in the field of language in mathematics education specifically in Africa. We use a particular configuration of multilingualism that permeates the complex linguistic landscape of the African continent – that is, one in which the LoLT is not the first or home language for a majority of students who learn mathematics. As Heugh (2024) vividly describes:

> "… complex histories and layers of human mobility, conquest, coloniality, epistemologies, practices of faith, languages, scripts and scholarship come together differently, with varying implications for the teaching and learning of mathematics in each setting" (p, XX).

Heugh (2024) further argues that multilingualism in Africa is not only multifaceted but also multiscaled within changing linguistic hierarchies. The focus of this review is a study of the teaching and learning of mathematics in Africa where, specifically, the language of power is not the majority language. Crucially, in this setting, the everyday/informal/social communication languages of the majority of school learners and so a crucial part of their linguistic/language repertoire is different from the LoLT.

Much of the recent review papers in top research journals in mathematics education has focused on the general context of language diversity without nuancing the different particularities inherent in the different linguistic contexts in their reviews (See Planas & Pimm, 2024; Radford & Barwell, 2016; Planas & Schütte, 2018). To our knowledge, there has been no systematic review focusing specifically on a linguistic context in which the LoLT is not the majority language, as is the case in Africa. This is notwithstanding a number of review papers and systematic reviews on multilingualism/language in the teaching and learning of mathematics in certain parts of Africa that have emerged in the last two decades. Setati et al. (2009), for example, did a scoping review focused on research that was done on language and mathematics between 2000 and 2007. Essien's (2018) review focused on language in early grade mathematics in three countries – South Africa, Malawi and Kenya. McLachlan and Essien (2022) reviewed research specifically in one journal – Pythagoras – on language and multilingualism in mathematics education from 1994 to 2021. Essien and Moleko's (2025) systematic review is perhaps the most expansive of all the above-mentioned reviews given that it focuses on research in multilingualism/language in the teaching and learning of mathematics in sub-Saharan Africa.

What distinguishes our current systematic review from previously conducted reviews on language issues in mathematics education in Africa are 1) its inclusion of not only journals published in English-dominant African countries, but also those published in Lusophone and Francophone countries making it more representative of the African continent; 2) the inclusion of book chapters given that some important papers on our topic of interest have been published in edited volumes. As we will discuss later, the inclusion of book chapters significantly expanded our included literature base. This has contributed to enabling us glean how research on the teaching and learning of mathematics in Africa has been advanced in ways that would have been impossible to ascertain and understand with only journal papers. In addition, we have selected to frame our review with an understanding of the orientations to language, knowledge, learning and teaching in school and in teacher education that, whether explicit or implicit, underpin claims and results from the surveyed literature. Our key aim of using these orientations is to be able to illustrate with reflection, substantive aspects of the research done in existing literature in the last decade.

Our review paper is, thus, informed by the following guiding questions:

- What research trends are evident in publications on language in mathematics education in Africa where the LoLT is not the majority language, and what are the characteristics of these publications in terms of foci, level, and method?
- What orientations to (1) language, (2) knowledge, and to (3) teaching and learning in (a) teacher education and in (b) school classrooms, inform research in this area?

In answering these questions, we hope to also engage with ways in which the field is being advanced and what gaps exists.

2 Framing the study: orientations underpinning researching practices in multilingual education contexts

Teaching and learning in school mathematics classrooms and mathematics teacher education are complex and multidimensional. Research on and in these equally so. All research is inevitably shaped by sets of assumptions related to the field. We use the term 'orientations' to mean assumptions, perspectives or dispositions that come together to frame research (and practice) in school mathematics classrooms and mathematics teacher education. As indicated previously, we bring to the fore four orientations - to language, to knowledge, to teaching and learning in teacher education, and to teaching and learning in school classrooms - that will in various ways and combinations inform and shape research on and in multilingual mathematics contexts. Whether explicit or not, research, whether on vocabulary and lexicalisation, on attainment in one or more languages, on mathematics and classroom discursive practices, or on the development of theories/methodologies, etc. is most likely shaped by at least one of these four orientations - each of these in itself complex. For our purposes in this paper, we delineate key aspects of each orientation that are likely to be at work in these studies.

2.1 Orientations to language

In any linguistic context, how linguistic repertoires of resources are harnessed for educational access is important. The extent to which this is evident in both research and practice is determined by one's language ideology, that is, the ideas and ideals one holds regarding language and language use (Sapire & Essien, 2021). Hence, language ideology is linked to a user's orientation towards language and shapes the assumptions about languages and their use that frame research in multilingual mathematics education contexts. In elaborating on orientation towards language, we draw on the pioneering work of Bakhtin (1981), the work of García and Wei (2014), Barwell (2016), and Sapire and Essien (2021). Bakhtin draws a distinction between a monoglossic/unitary-oriented (monoglossia) and a heteroglossic-oriented ideology (heteroglossia) and argues that these are at the opposite ends of a spectrum. Drawing on Bakhtin, Barwell (2016) argues that in the unitary language perspective (monoglossia), the emphasis is on a single language and single language use, and languages are reified as distinct and uniform entities. Monoglossic ideologies, therefore, treat languages as bounded autonomous systems and are based on a purist view of language. Heteroglossic ideologies, on the other hand, recognise multiple practices in language use in interrelationships (García & Wei, 2014) and are therefore based on a pluralist view of language. As further discussed by Sapire and Essien (2021), in a heteroglossic view, there is recognition of the fact that speakers have a language repertoire of more than one language that can/should be drawn upon in a fluid manner when they speak.

Barwell (2016) argues that orientations to language ideologies are typically not explicit in research studies. Using the case of code-switching, he argues that while it may appear that code-switching as a practice is heteroglossic, the opposite may be the case if what is promoted is what others (e.g. Sapire & Essien, 2021) have referred to as multiple monolingualism where only one of the languages present in the class is used at any one time as if speakers are monolingual, and/or where the languages are treated as analytically distinct from one another.

In our analysis, described in Table 1 below, we discerned whether the orientation to language in the surveyed research outputs is monoglossic or heteroglossic. It is important to state clearly here that the orientation we discern is that adopted by the researchers/authors for the study reported as gleaned from the research output at hand. A research output's orientations will be discerned using the criteria and indicators in Table 1, and likely to be indicated by whether the approach in the paper ultimately promotes (however implicitly) a single language use for mathematics teaching and learning– a purist approach; or multiple languages and so a pluralist approach.

2.2 Orientations to knowledge

In addition to language ideologies being at work in research and practice, and not necessarily visible or explicit, so too are orientations to knowledge and what it means to come to know or to learn – in other words, knowledge building. We draw here on Heugh (e.g. 2021, 2024), a longstanding specialist in multilingual education policy and practice in Africa and the Asia Pacific, and her argument that:

> "Multilingual education … is more than about language and the communicative functions of language, it is also about how best to translate, share and exchange knowledge, or to 'transknowledge', in a reciprocal manner among local, regional, national and even international communities" (2021, p. 40).

Heugh (2021) promotes a 'functional' view of multilingual education, which distinguishes its 'horizontal' from 'vertical' dimensions, both of which are crucial for sharing knowledge and its growth and so for learning. In much of Africa, multilingual practices of code-switching and code-mixing are central to building social cohesion and equitable

Table 1 Indicators for the orientations to researching practices in multilingual education contexts

Orientations	Dimensions	Descriptors
Orientations to Language	Monoglossic CODE: Mon	-*purist views of language* in focus (or can be inferred) and seen as beneficial to T&L
		-Language perceived as discrete and bounded systems, thus promoting situations of multiple monolingualism
	Heteroglossic CODE: Het	-*Pluralist views of language* in focus (or can be inferred) and seen as beneficial to T&L
		-Promotes multilingualism rather than multiple monolingualism
Orientations to knowledge	Horizontal CODE: Hor	-focus is on eliciting and connecting with students' everyday knowledge and meanings
		-translanguaging or switching is between everyday/informal communicational practices across languages
	Vertical CODE: Ver	-focus is on mathematical registers (in one or more language) and so on specialised discourse, scientific concepts
		-Focus on switches across registers either within or across languages
A **functional orientation** would be where there is presence of heteroglossic, horizontal and vertical (Het+Hor+Ver).		
Orientations to teaching and learning in mathematics teacher education	Teachers as becoming learners of mathematics content Code: BLMC	-Focus is on inducting teachers into understanding the mathematics content
		-Focus is on becoming knowledgeable about mathematical content
	Teachers as becoming teachers of mathematics Code: BTM	-Focus is on the PST/in-service teachers (IST) as a teacher of mathematics
		-Focus is on teaching for the teaching of mathematics
	Teachers as becoming learners of mathematical practices? Code: BLMP	-Focus is on teaching/learning that enculturates teachers into becoming knowledgeable about mathematical processes (such as the process of defining/exemplifying, etc.) rather than the content.
		-Focus is on the importance of a particular practice or particular practices and what makes for a 'good' practice.
		-Focus on becoming knowledgeable about mathematical processes.
	Teachers as becoming teachers of mathematics in multilingual classrooms? Code: BTMMC	-Focus is on how teaching (and learning) induct(s) teachers into becoming teachers of mathematics in multilingual contexts
	Teachers as becoming proficient language users Code: BPLU	-Focus is on how a natural language is used – where there was teaching for developing proficiency in the LoLT.
		-Focus on LoLT for PST/IST's own meaning-making, and for the purpose of teaching
Orientations to teaching and learning in mathematics classrooms	Mathematical concept development Code: MCD	-Focus is on developing mathematical concepts
		-Focus is on access to mathematics content
		-Focus is on representations in mathematics
		-Focus is on mathematical practices
	Mathematical language fluency development Code: LFD	-Focus is on language fluency
		-Focus is on mathematics register and discursive work of mathematics, particularly in the LoLT
	MCD + LFD = INT (integration of content and language)	
	Enabling Participation Code: EP	-Focus is on interaction in class and the norms (both mathematical and social) that enable productive mathematical engagement

inclusion and a fundamental part of everyday life – some would say their lingua franca. Heugh (2021) refers to these informal translations, interpretations and use of peoples' language repertoires as 'horizonal multilingualism', defined as a "fluid moving back and forth between languages often for communal and convivial socio-economic functions" (p. 44). Indeed, as we see in the many papers reviewed here, informal classroom talk is often characterised by fluid mixing of languages (e.g. Bowden et al., 2024).

Heugh (2021) contrasts informal horizontal multilingualism with 'vertical multilingualism' bringing to the fore the significance of movements across 'registers' (Halliday, 1978), where switches in language (and this could be within a language and across registers, or across languages in order to move to a different register) serve functions other than social communication. Of specific interest to us here then, are functions that serve mathematical learning, and the critical point that vertical switches include formal written and spoken processes/practices of translation and interpreting. Unlike the informal fluid horizontal multilingualism in informal and social communication, Heugh (2021) argues that vertical multilingualism in education requires systematic and purposeful use. What this means for classroom practice is that vertical switches and related use of code-switching and code-mixing need to be systematic and purposeful if they are to serve educational purposes and so enable access to different forms of knowledge, and knowledge building.

The significance of vertical multilingualism is contested by some authors (e.g. Bowden et al., 2024), and hinges on the politics of access to the language of power and so complex equity issues. This debate extends beyond our scope here but is important for work going forward. For Heugh, and we agree, students need to be given access to and develop their repertoires in "both horizontal and vertical dimensions of multilingualism and also in both spoken and written modes" (2021, p.38). Horizontal and vertical multilingualism are thus not in opposition. Both are important for knowledge growth and learning.

In our analysis, we discerned whether and how access to mathematical ideas, concepts, and processes are in focus, and how language use is associated with these. Thus, orientations to language intersects with orientations to knowledge building, and we represent this in Fig. 1 below. Heteroglossia could function at the level of language use for social purposes, and so only at the level of horizontal multilingualism, hence our attention in Table 1 not only to monoglossic and heteroglossic orientations to language, but within each, whether these include attention to horizontal movement across languages and/or vertical movement within and/or across languages. Like Heugh (2021), we refer to such a situation as functional multilingualism. By functional multilingualism, therefore, we mean situations where

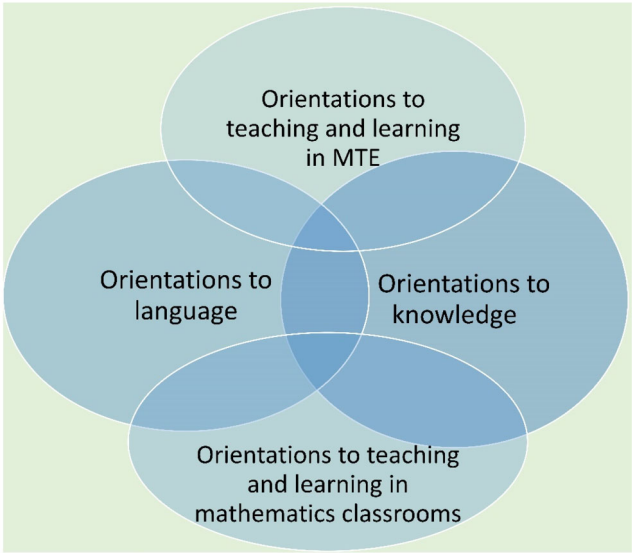


Fig. 1 Orientations to researching practices in multilingual education contexts

the orientation is at once heteroglossic, horizontal and vertical. This last point is particularly important, and we return to it as we elaborate the coding for our analysis in Table 1.

Figure 1 also shows further intersections of the other two orientations – to teaching and learning in MTE, and to teaching and learning in mathematics classrooms – with orientations to language and to knowledge. As noted, these arise from our experience in the field, where much of the empirical work is located in either or both of mathematics teacher education (MTE), and school classrooms. These then invoke orientations to teaching and learning, with the teacher as learner in the former and student as learner in the latter. We have thus separated these in the figure, and we deal with these in turn.

2.3 Orientations to teaching and learning in mathematics teacher education (MTE)

Our contention is that in MTE, while it is important to include disciplinary knowledge, it is also important that there is attention to, or knowledge about the context of practice and instructional practices. Our understanding of the orientation to teaching and learning in mathematics teacher education centres on what is the focus of research in terms of attention to the interacting teacher identities in play (Essien, 2014). Hence, even though the site is teacher education (teacher as learner), our key interest is specifically in how the identity of the teacher is constructed in the corpus of literature under review. Drawing on Wenger's (1998) notion of identity as a constant becoming, Essien (2014) elaborated on how this identity translates into teacher education in the context of language diversity by proposing what he calls the 5

interacting identities/multifarious dimensions in teacher education that deal with content, teaching mathematics, mathematical practices, teaching in multilingual context and language development. These identities are interrelated and in constant interaction in any multilingual mathematics teacher education setting. In examining our corpus of literature, of particular interest for our review was to examine evidence present in the research outputs in support of the multiple and interacting layers involved in teacher education for enculturating teachers into 1) becoming learners of mathematics content; 2) becoming teachers of mathematics; 3) becoming learners of mathematical practices; 4) becoming teachers of mathematics in multilingual classrooms; and 5) becoming proficient language users for the purpose of teaching and learning mathematics (see Essien, 2014, and the methodology section below for an elaboration of these interacting identities). Hence studies in and of MTE will reflect all or some of the orientations to teacher identities that intersect with both language and knowledge orientations.

2.4 Orientations to teaching and learning in mathematics classrooms

As with MTE and as depicted in Fig. 1, studies in and of teaching and learning in mathematics classrooms will reflect orientations to learners becoming doers and speakers of mathematics, again intersecting with orientations to language and knowledge. These orientations deal with assumptions that are projected, implicitly or explicitly, of multilingual classrooms as simultaneously requiring opportunities for learners' access to mathematics; access to language; and/or access to norms (both social and mathematical) in the classroom (Adler, 2001). Access to mathematics entails assumptions that are made with regards to both the registers (c/f Halliday, 1978), representations and the discursive work of mathematics and its teaching and learning in school (Prediger, 2022). Access to language entails learners becoming fluent in the way we argue and use words, specifically in the LoLT. Assumptions about norms entail the extent to which attention is paid (or not) to regularities in multilingual classroom environments for enabling of what Engle and Conant (2002) refer to as productive disciplinary engagement. In distinguishing these orientations, we engage with whether the focus of the research output is more on developing mathematical concepts, or on language fluency (in the LoLT) or both, i.e the integration of language and content in Prediger's (2022) terms.

As indicated previously, given that these orientations were derived from theory rather than empirical study, our contention is that research in the field of multilingual mathematics will make assumptions, implicitly or explicitly, that focus on one or more of these orientations, and in overlapping ways.

Our separation of orientations in relation to research in MTE and in school classrooms, both in our discussion above and in Fig. 1 is thus intentional. We are cognisant of course, that in MTE there are always underlying assumptions about learning and the learner. In research on learning, there are also, but less obviously, assumptions about teacher and teaching. Our analysis, however, is not sufficiently refined to engage with this additional complexity, hence the separation.

To elaborate further, the practice of and/or research on mathematics education in multilingual contexts can focus on/can be analysed (perhaps at one point in time or the other) through the orientations to language and/or the orientations to knowledge (hence the overlap). The other two orientations – both to teaching and learning – denote the specificity of the orientations as they relate to the two key 'sites' of research: (a) teacher development spaces (in-service and pre-service) and (b) primary and secondary classrooms. Each of these latter orientations shapes and is shaped by the orientations to language and the orientations to knowledge (in both research and practice).

3 Methodology

3.1 Inclusion criteria

We searched through both mathematics education journals and general education journals across Africa for research outputs where the LOLT is not the majority language (i.e. the language spoken at home by the majority). This meant looking through publications in all 54 countries in Africa, including Francophone, Anglophone and Lusophone countries. For international mathematics education journals, we used the list of the top 20 mathematics education journals by Williams and Leatham (2017). For all journals in Africa (both mathematics education and general education journals), we used Google Scholar, and the African Journals Online (AJOL) platform which houses the largest collection of African-published scholarly journals. For general education international journals, we focused on language and education journals (e.g. Language and Education); and education development journals (e.g. International journal of educational development). We also included book chapters (from key publishing houses) where the focus is on language and mathematics education, or education and society, or where the context is focused on mathematics education research in Africa. More specifically, we included publications from Springer; Routledge; Erlbaum; Bloomsbury; Palgrave; Brill. Three key criteria were used as inclusive criteria for research outputs from the above outlets:

i) The context is a linguistic context where the majority language is not the language of teaching and learning;

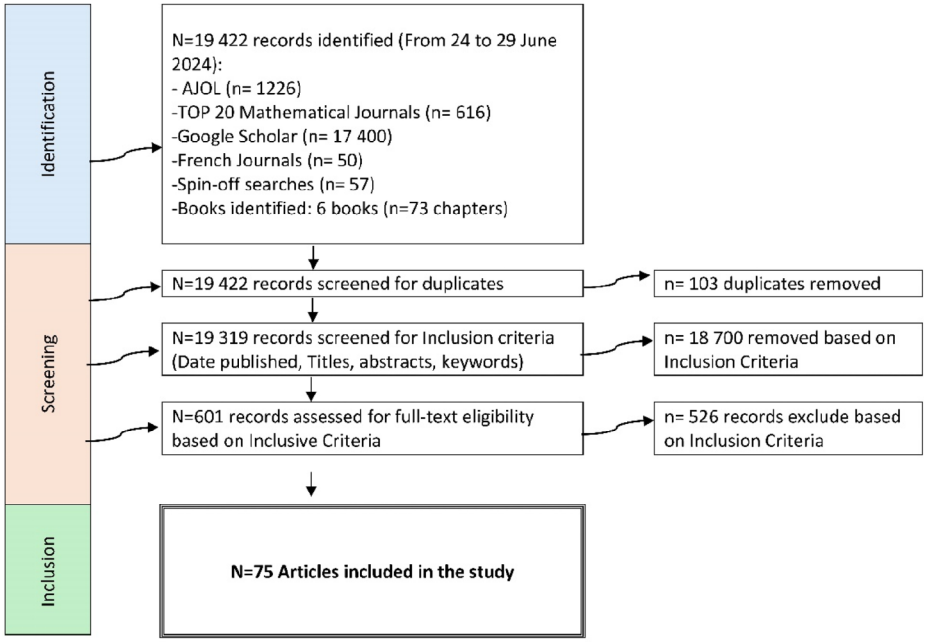


Fig. 2 Article search and screening process

ii) The context in which the research output is imbedded needed to be the teaching and/or learning of mathematics in Africa;
iii) The research output needed to be published from 2015 to 2024.

A research output needed to satisfy all the above three criteria simultaneously to be included, irrespective of the geographical location of the publishing author(s) of the research output. We used the following key words to search the internet and specifically, African Journals Online: mathematics, multilingual(ism), language, dialogue, discourse, semiotics, discussion, communication, translanguaging, and mother tongue. We also conducted a 'spin-off' search which involved 1) searching of the references of the initial articles selected; and 2) searching for publications of leading authors on the African continent. We are convinced that this spin off search enabled a more comprehensive result of research outputs even though some words (e.g. 'interaction') were not part of our search terms.

From a literature base of 19,422 publications, after applying the inclusion (and exclusion criteria), we found 80 articles for analysis in our systematic review, with deeper analysis having us remove five of these 80 papers, and so a final total of 75 papers as shown in Fig. 2. These are listed in Table 7 (see supplementary materials), with the original numbering.

3.2 Characterising and coding of reviewed publications

To characterise each of the 75 papers, we captured the year, title, author(s), countries (where research carried out), participants, methods, and level, as reflected in Table 7 (see supplementary materials).

To capture the orientations, two levels of iterative coding were involved in the processes of trying to organise the reviewed papers, viz, moving back-and-forth between inductive and deductive approaches. First, the codes for analysing the orientations were deductively derived from our theoretical elaboration of what these orientations entail. Then we selected altogether 10 papers to read individually and make a first attempt at coding. We then met to compare and discuss our individual codes. Through this process, we refined the descriptors for the codes. We continued to meet to collaboratively compare and discuss, and refine our coding of the remaining papers, and through this process, continued to refine the descriptors for which the final product is Table 1.

Having detailed the coding used, we need to draw attention, as noted earlier, to coding for horizontal orientations to knowledge. This entails connecting to students everyday/informal meanings. This can thus be within a language (and so moving between the everyday/informal and more formal registers within a language). It can also be across languages (and so movement across informal/everyday registers in more than one language) as needed in a multilingual context. We also identified cases of this in our data (see, for example, the analysis of paper 1 in Table 6 in the Appendix), where horizontal and vertical movement(s) were present within one language (hence a monoglossic orientation to language). A situation like this will mean that the paper promotes the Horizontal and Vertical dimensions in one language rather than in more than one language.

Table 2 Number and type of publications by year

Year	African journal	International journal	Book (chapters)	Total
2015	0	1	0	1
2016	7	1	5	13
2017	2	0	0	2
2018	5	3	0	8
2019	5	3	0	8
2020	5	5	0	10
2021	1	2	5	8
2022	1	5	4	10
2023	1	2	0	3
2024	0	1	11	12
TOTAL	**27**	**23**	**25**	**75**

4 Results and discussions

In this section, we first present a descriptive summary of the reviewed literature and subsequently engage with visible trends in research on multilingualism in mathematics education in Africa. We present trends through our characterisations in terms of publication distribution based on year of publication, methodological approaches used in the reviewed literature, and geographical distribution of publication from 2015 to 2024. We then engage with the key issue of orientation in focus and what this means for research progression in research on multilingualism in the teaching and learning of mathematics on the African Continent.

4.1 Research trends on language in the teaching of mathematics in Africa

Table 7 (see supplementary materials) shows a global picture of the data from the surveyed literature. This global picture will be used in the subsequent sections for a more granular analysis of the trends on research on language in mathematics education in Africa.

4.1.1 Publications by year

Table 2 shows a rather erratic trend in publications per year. 32 publications are recorded in the first five years of the review period, and 43 publications are recorded in the last five years. This increase in the second half of the review period, as Table 2 shows, is as a result of book chapters.

4.1.2 Geographical distribution

A clear finding evident from Fig. 3 is that, like in Essien and Moleko's (2025) review, most of the publications are from South Africa. This clearly indicates that attention is being paid to language and multilingual issues in the teaching and learning of mathematics in South Africa compared to other parts of Africa. This may be due to research funding infrastructures in South Africa, and the presence of a strong mathematics education community. Another explanation for this lies in the fact that the pioneering work that was done on multilingualism, and on the intricacies of mathematics teaching and learning in multilingual classrooms started in South Africa with the work of Adler and Setati (See Adler, 1995, 2001; Setati & Adler, 2000) as indicated previously.

But the reality is that most other African countries are more linguistically diverse than South Africa, and the nature of multilingualism varies across different linguistic settings in Africa (Essien et al., 2024). As such, these countries will benefit from research that focuses on the dynamics of teaching and learning of mathematics that is particular to their contexts given their specific nature of multilingualism. It is our contention that the field will benefit from the knowledge gained through these more varied research contexts. Table 3 provides an indication as to the type of publications from each of the countries.

While there is spread across publication types and countries, four countries (Algeria, Morocco, Uganda and Tanzania - Zanzibar is included in Tanzania) make an entry into the field through book chapters only. Perhaps, the point we make below for Francophone and Lusophone countries regarding conference publications would also apply to these four countries, and explain the current paucity of journal papers.

What about francophone and lusophone? We set out to include publications in French and Portuguese that respond to our inclusive criteria – but have found only 1 French paper in the journal range – and no Portuguese publications. What we realised, a function of references and knowing those working in the field, is that there are many such publications focused on language and mathematics teaching and learning, but all appearing in conference proceedings such as EMF – Espace Mathématique Francophone; ADiMA – Association des Didacticiens des Mathématiques Africains de l'Ouest

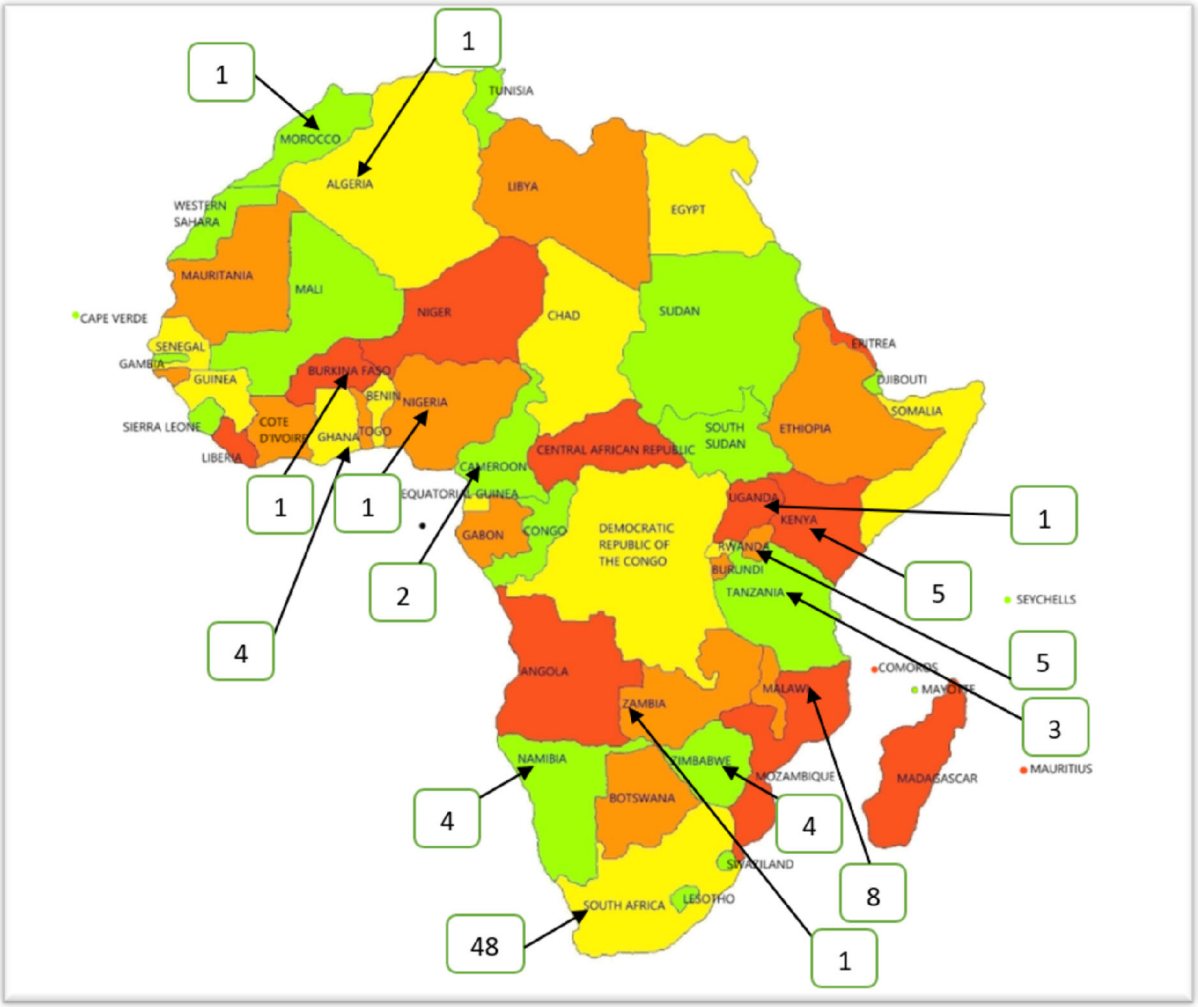


Fig. 3 Geographical distribution of the surveyed literature (different colours are used simply to visually separate the countries)

et du Nord; EMeLP (The Mathematical Space in the Portuguese Language). It is beyond the scope of this paper to engage with whether and how this points to a different kind of linguistic discrimination or marginalisation as some publications from, especially French speaking authors, are written in English.

4.1.3 Publication type (journals, book chapters)

We attend to publication type having become aware, particularly through the inclusion of book chapters, of just how complex this terrain is for both research and practice. Of the 75 surveyed outputs, 25 (i.e. a third) were book chapters, with a relatively large number in recent years. Eleven book chapters were published in two volumes in 2024 (e.g. Essien, 2024; Reilly et al., 2024). What these edited volumes accomplish is that they make visible issues of research and practice across Africa and subdue at least a little, as discussed above, the dominance of South African research across the terrain.

In our analysis on when and then where papers emerged, growth and spread are evident, both quantitatively, and across countries. This growth is made visible at least in part by the inclusion of book chapters in our review. As participation in the field grows through conference participation and engagement, establishing a fuller picture (particularly in newly participating countries, and countries where English is not the privileged language) will require extension in systematic reviews to conferences, together with critical attention to relevant criteria for inclusion (e.g. the nature of review processes for inclusion in conference proceedings).

4.1.4 Methodological basis of studies and level (primary, secondary, TE)

Table 7 in the supplementary material clearly indicates that the dominant methodology used in research across the continent is the qualitative approach. This resonates with previous reviews (eg, Setati et al., 2009), where there were

Table 3 Type of publications linked to geographical location

Country of research	African journal	International journal	Book (chapters)	Total
Algeria			1	1
Burkina Faso	1			1
Cameroon	1	1		2
Ghana	1	2	1	4
Kenya	1	2	2	5
Malawi	2	2	4	8
Morocco			1	1
Namibia	1	1	2	4
Nigeria	1			1
Rwanda		2	3	5
South Africa	22	10	16	48
Tanzania			2	2
Uganda			1	1
Zambia	1	1		2
Zanzibar			1	1
Zimbabwe	2	1	1	4

Table 4 Methodological approaches used in the surveyed literature (multiple coding on some papers)

Level	Total number	Qualitative	Quantitative	Mixed method
Primary	41	32	4	5
Secondary	24	19	3	2
Teacher Educ	15	12	1	2

Table 5 Summary of orientations across the 75 papers (See the Appendix for an expanded version)

	Orient lang		Orient knowledge		Functional orient	Orientation to mathematics teacher education					Orientation to TL in classrooms			
	Mon	Het	Hor	Ver		BLMC	BTM	BLMP	BTMMC	BPLU	MCD	LFD	INT	EP
#	11	64	49	48	46	29	30	22	46	52	49	66	43	41

few quantitative or mixed method approaches used. We also noted few longitudinal studies. Table 4 re-presents the methodologies used, and in addition, summarises the approaches according to levels of education.

In terms of levels, Table 4 shows a dominance of research at the primary level (41 counts) as compared to Secondary level (24 counts) and Teacher Education level (15 counts). What this suggests is that more than 15 years after the findings of Setati et al. (2009) on the lack of publications at teacher education level, we are beginning to see a rise, even though research in teacher education still trails behind research at the primary and secondary levels. The volume of research at the primary level is further interesting (and a recent phenomenon) when compared to earlier reviews which showed paucity of research focusing on language and mathematics at the primary level (see for example, Setati et al., 2009).

There is research and certainly concern with educational policy pertaining to multilingualism as we have outlined across diverse countries. A number of these papers at the same time, do not report results of empirical studies. However, their contribution lies in giving voice to the challenges ahead for policy and practice, and this is at a number of levels – in school classrooms, in teacher education, and in supporting textual materials particularly textbooks.

4.1.5 Orientations in focus

Table 5 presents the summary of orientations of research outputs across the 75 papers, as revealed through our coding (see Table 7 in supplementary materials for an expanded version of this table). In the discussions below, we deal with each of the four orientations, starting with language and knowledge together, as these interact in relation to functional multilingualism, depicted as well in Table 7.

Orientations to language and knowledge: As indicated in Table 5, the vast majority of the 75 papers, be these book

chapters or journal papers, in local or international journals, reflect a heteroglossic orientation to language, and thus a view that multiple languages in use - language plurality - matters in multilingual mathematics education. At one level, this is no surprise, and reflective of a broader shift across the world, that all language resources should be harnessed for learning (Barwell, 2016; Graven & Robertson, 2020; Kazima et al., 2023; Essien et al., 2016; Halai, 2016). In the context of our review, where the LoLT is typically not the majority or dominant language, there is a widespread and strong view that the use of indigenous, spoken language(s) are central to the educational project. How this interacts with the LoLT and so access to mathematics in the LoLT is where complexity lies. What is thus both interesting and important is whether the orientation is functional, and so heteroglossic with both horizontal and vertical orientations. What our study reveals is that the authors of over 60% (46 out of 75 papers) of the papers simultaneously reflect an orientation to knowledge growth – the epistemic - and concern with how languages in use support functional multilingualism (Heugh, 2021).

If we tease this out further, a majority of 60% of papers that reflect a functional orientation to language also reflect the authors' concerns with moving between multiple language resources for sense-making (meaning-making). In fact, only 3 of the 46 functional orientation papers reflect vertical and horizontal movements of registers (in the Hallidayan sense) within one language. The remaining 43 papers are concerned with vertically and horizontal movements across multiple languages to enable progression of mathematical thinking and knowing. This is why we are discussing both language and knowledge orientations together.

Finally, it is important, nevertheless, to understand that these orientations to language and knowledge do not reflect empirical results of improved learning. A notable absence is that there are very few studies in our corpus of literature that deal with attainment when functional multilingualism is in place, and so a great deal of work lies ahead in this respect.

Orientations to mathematics teacher education: The orientations with greater prevalence here are first to 'Teachers as becoming proficient language users' (BPLU – 52). We learn from the fact that two thirds of the papers see the importance of teachers themselves becoming more proficient in the LoLT on the one hand, and/or being able to use their own languages as resources for their own meaning-making. This signifies perhaps one of the characteristics of the context of multilingualism we address in this paper. In contexts like Africa where the majority language is not the language of teaching and learning, teachers themselves are not necessarily fluent in the LoLT – indeed as with the students in their classrooms. Many will have developed some fluency of course, as they could not have concluded their studies towards being teachers, but this is not the same as being a mother tongue speaker of the LoLT. At the same time, most teachers then are themselves multilingual and so more able to draw on the multiple languages present in their classrooms.

The next prevalence is 'Teachers as becoming teachers of mathematics in multilingual classrooms (BTMMC – 46). As noted earlier, code-switching has not had wide legitimacy in the past, given the politics and power of colonial languages and the LoLT, indicating that it is not a straightforward given that the benefits and constraints on drawing on multiple languages in teaching and learning mathematics is widely understood (Setati & Adler, 2000). That authors are oriented to this in papers directly concerned with MTE, or reflecting on the outcomes of a study for MTE is thus not surprising.

The question that arises is whether this focus on language(s) use is at the expense of attention to mathematical content. Overall, we were interested to see that for a third of the papers, there appeared to be simultaneous attention to language and the epistemic (Prediger, 2022) in teacher education too. This lower occurrence suggests the complexity of attending to all the interacting developing needs of teachers in multilingual classrooms, and work up ahead for greater attention towards integration of language learning goals and content learning goals.

Orientations to classroom teaching and learning: A key finding under the orientations to classroom teaching and learning is the predominant orientation to developing language fluency of learners in multilingual mathematics classrooms (LFD) across the papers - 66 of the 75 - and so 88% of the papers. Here we see greater attention to integration (INT) of content and language. More than half the papers, when reflecting an orientation to teaching and learning were also concerned with mathematics concept development, and so with an orientation to teaching and learning that integrated content and language.

Thus if we look across all four orientations, there is some consistency across these towards a functional approach to multilingual education, and the integration of content and language in and for teaching and learning, as well as teacher education. The stronger figures in MTE and classroom teaching towards language fluency also suggests, nevertheless, that attention to fluency for both teachers and learners, no doubt in the LoLT, remains in the foreground, linking in with the international literature that has argued on the one hand, that expressed advocacy of heteroglossia is not necessarily reflected in practice (Barwell, 2016). 41 of the papers (about 55%) deal with enabling participation in class, and thus suggesting that in the corpus of literature under review, concerns about interaction in class and the norms that enable productive mathematical engagement are also seen as

important. Of the 41 papers focusing on enabling participation, 35 also focus on epistemic access and so on ways of arguing and reasoning mathematically (Prediger, 2022). This latter brings back into focus the debate on functional multilingualism and the roles of different languages in the development of registers for formal purposes.

4.2 Noticeable absences

A number of absences have been discussed in previous sections. Notable among these is the fact that more research dealing with attainment when functional multilingualism is in place, is needed. It is important that there are empirical studies on whether and how functional multilingualism fosters learning and so knowledge building.

Also, in terms of geographical distribution of publications, we have noted a geographical dominance of South Africa and the language dominance of English. There are silences in publications from the Francophone and Lusophone parts of Africa. There are also English-speaking countries which are not represented in the geographical distribution of publications. Some of these countries have a high degree of language diversity, and as such, bringing in the particularities of their own linguistic contexts through research has the potential of greatly enhancing and broadening our understanding of language issues in the teaching and learning of mathematics. Present amongst these absences are studies and reflections in book chapters from a wider range of countries, and as we have posited, critically informed inclusion of conference proceedings would expand our insight into issues and advances in this field, in a wider range of countries and contexts.

5 Conclusions and limitations

With respect to orientation to language and knowledge, the overwhelming orientation is functional multilingualism, and thus an increasing appreciation of the way in which language use is profoundly epistemic – language and content working together in practice, suggesting that studies should be similarly focused. Notwithstanding this trend, and as discussed earlier, there remains debate on whether and how different language(s) in use can and should support verticality. This debate is beyond the scope of our review here, but briefly, Bowden et al. (2024) show in their paper reviewed here, how secondary mathematics teachers in Rwanda use students' spoken language to explain ideas, but technical terms are voiced in English – an indication that these terms are not readily available in the other language(s) in use. From the scope of work reported, it is not apparent how this fluid mix of languaging (technical terms in the LOLT, with elaboration in home language) supports movement between registers and elaborated discursive participation in mathematical practices. It is also, crucially, not apparent how and in what language(s) mathematical ideas are recorded/written by students themselves (and so required in formal assessments), nor how this work of teaching is supported by textbooks and the language(s) used in these. It is typically the case, particularly at the secondary level that curriculum materials are in the LOLT and only in one language. More empirical study is needed, and this points to some of the important work that lies ahead.

This discussion raises a question as to whether there are significant differences in how heteroglossia, and functional multilingualism supports elementary as well as secondary teaching/learning and whether there are differences. Recent research in South Africa at the primary level (Sapire & Essien, 2021; Robertson & Graven, 2024; Venkat & Morrison, 2024) points to developments in early school learning where supporting textbooks and curriculum materials are being developed using more than one language. Research reported in Malawi (e.g. Kazima et al., 2023) brings the complexity of functional multilingualism to light at the elementary level as it shows that there is a lack of consistency in language in use in early grades across textbooks (which are in a local language), teacher guides (that are in English), languages in teacher education (formal English and informal translanguaging) and in school practices (in local languages). This works against rather than in support of mathematics teaching, leaving the crucial work of systematic and deliberate translanguaging to teachers' day-to-day practice.

The summary numbers for horizontal and vertical orientations to knowledge (49 and 48) and that it is 46 of the 64 papers (see Table 5) that are oriented to functional multilingualism also require some comment. These show firstly that there are papers reflecting a heteroglossic orientation to language, but do not simultaneously attend to the epistemic. Also present but masked in these figures are papers (eg Mulwa, 2015) that are monoglossic, but nevertheless are concerned with connecting to student meaning making (though in one language only) and so with a horizontal orientation to knowledge, and moving across registers (again in one language only).

Finally, as with any study, this review has a number of limitations: 1) Our analysis of the surveyed data in term of orientations does not disaggregate the levels of schooling (primary, secondary, and TE); We also have not disaggregated the horizontal/vertical and monoglossic/heteroglossic in detail. All these disaggregations could have led to further findings; 2) the continued impact of research in Africa on multilingual classrooms is not engaged with. These limitations point to critical work that lies ahead and the basis, at least, of a further paper on the data here that zooms in to take these forward.

In conclusion, it is only through continued and sustained efforts of research on language in mathematics education,

that Africa can continue to be at the cutting-edge of research in the field and lead the world on research pertaining to language diversity in mathematics education. Dissemination, including through systematic reviews such as this, contribute to African research continuing its role of "setting the research agenda and theorizing its different dimensions" (Barwell, 2024, p. 219).

Appendix: Coding schedule for included papers

Table 6 Coding Schedule for included papers

#	Article title	Orient lang		Orient knowledge		Functional orient	Orientation to mathematics teacher educ					Orientation to TL in classrooms			
		Mon	Het	Hor	Ver	(Y/N)	BLMC	BTM	BLMP	BTMMC	BPLU	MCD	LFD	INT	EP
1	Mulwa	1	0	1	1	1	NA	NA	NA	NA	NA	1	1	1	0
2	Barwell et al	0	1	1	1	1	1	1	1	1	1	1	1		1
3	Jantjies & Joy	0	1	0	0	0	0	1	1	0	0	0	1	0	0
4	Halai	0	1	1	1	1	1	0	1	1	1	1	1	1	1
5	Feza	0	1	1	1	1	NA	NA	NA	NA	NA	1	1	1	1
6	Mulaudzi	0	1	0	0	0	0	1	0	1	1	0	1	0	1
7	Le Roux	0	1	1	1	1	1	0	0	0	1	0	1	0	1
8	Chikiwa & Schaefer	0	1	1	1	1	1	0	0	1	1	1	1	1	0
9	Tyler	0	1	1	1	1	1	1	1	1	1	1	1	1	0
10	van Jaarsveld	1	0	1	1	1	1	1	0	1	1	1	1	1	0
11	Umeodinka & Nnubia	1	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Durand-Guerrier et al	0	1	1	1	1	NA	Na	NA	NA	NA	1	1	1	0
13	Essien et al	0	1	1	1	1	1	1	1	1	1	1	1	1	1
14	Thompson et al	0	1	1	1	1	1	0	0	1	1	1	1	1	1
20	Sibanda	1	0	0	0	0	0	0	0	0	0	1	1	1	0
21	Mahofa Adendorff & Kwenda	0	1	0	1	0	0	0	0	1	1	1	1	1	1
22	Sibanda and Graven	0	1	1	1	1	NA	NA	NA	NA	NA	0	1	0	1
23	Essien	0	1	1	1	1	1	1	1	1	1	1	1	1	1
24	Chikiwa & Shafer	0	1	1	1	1	1	1	1	1	1	1	1	1	1
25	Stoffelsma & Spooren	0	1	0	0	0	0	0	0	0	1	0	1	0	0
26	Robertson & Graven	0	1	1	1	1	NA	NA	NA	NA	NA	1	1	1	1
27	Ledibane Kaiser van der Walt	0	1	0	1	0	0	1	0	1	1	0	1	0	0
28	van Jaarsveld	0	1	1	1	1	1	1	0	1	1	1	1	1	0
29	Maluleke	0	1	0	0	0	0	0	1	1	1	0	1	0	0
30	Makonye	0	1	1	1	1	0	0	0	0	0	1	1	1	1
31	Julius	0	1	0	0	0	0	1	1	1	1	0	1	0	0
32	Robertson & Graven	0	1	1	1	1	1	1	1	1	1	1	1	1	1
33	Prince & Frith	1	0	0	0	0	1	1	0	0	1	1	1	1	0
34	Robertson & Graven	0	1	1	1	1	0	0	1	1	1	1	1	1	1
35	Tshuma & le Cordeur	1	0	0	0	0	0	1	0	0	1	0	1	0	0

Table 6 (*Continued*)

#	Article title	Orient lang		Orient knowledge		Functional orient	Orientation to mathematics teacher educ					Orientation to TL in classrooms			
		Mon	Het	Hor	Ver	(Y/N)	BLMC	BTM	BLMP	BTMMC	BPLU	MCD	LFD	INT	EP
36	Cekiso Meyiwa & Mashige	0	1	0	0	0	0	1	0	1	1	0	1	0	0
37	Robertson & Graven	0	1	1	1	1	1	1	1	1	1	1	1	1	1
38	Smith, Julie, Gierdien	1	0	0	0	0	1	0	0	0	1	1	1	1	0
39	Mambwe, Z Ndhlovu	0	1	0	0	0	0	0	0	1	1	0	1	0	0
40	Seudib	0	1	0	0	0	0	0	0	1	1	0	1	0	0
41	Omidire	0	1	0	0	0	0	0	0	1	1	0	1	0	0
42	Nhongo & Tshotsho	0	1	0	0	0	0	0	0	1	1	1	1	1	0
43	Chikodzi-Kaino	0	1	0	0	0	0	0	0	1	1	0	1	0	0
44	Mostert & Roberts	0	1	1	1	1	1	1	1	1	1	1	1	1	1
45	Mostert	0	1	1	1	1	1	1	1	1	1	1	1	1	1
46	Lingani	0	1	1	1	1	1	1	0	1	1	1	1	1	0
48	Mawela, S Mahlambi	0	1	0	0	0	0	0	0	1	1	0	1	0	1
49	Chikiwa	0	1	1	1	1	1	0	0	1	1	1	1	1	0
50	Bayaga Khalo Moyo	1	0	1	1	1	0	0	0	0	0	1	1	1	0
51	Sibanda	0	1	1	1	1	NA	NA	NA	NA	NA	0	1	0	0
52	Pitchford et al	0	1	1	1	1	0	0	0	1	1	0	1	0	1
53	Le Roux et al	0	1	1	1	1	NA	NA	NA	NA	NA	1	1	1	1
54	Poo & Venkat	0	1	1	1	1	1	1	1	1	1	1	1	1	1
55	Sapire & Essien	0	1	1	0	0	NA	NA	NA	NA	NA	1	1	1	1
56	Meremikwu et al	1	0	0	0	0	1	0	0	0	0	1	0	0	0
57	McLachlan & Essien	0	1	1	1	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
58	Bowden et al	0	1	1	0	0	NA	NA	NA	NA	NA	1	1	1	1
59	Kuchah et al	0	1	0	0	0	NA	NA	NA	NA	NA	0	0	0	1
60	Norro	0	1	1	0	0	NA	NA	NA	NA	NA	0	0	0	0
61	Planas et al	0	1	1	1	1	1	1	1	1	1	1	0	0	0
62	Feza et al	0	1	1	1	1	0	1	0	1	1	1	0	0	0
63	Porteus	0	1	1	1	1	1	1	1	1	1	1	1	1	1
64	Roberts et al	0	1	1	1	1	1	1	1	1	1	1	1	1	1
65	Venkat & Roberts	0	1	1	1	1	1	1	1	1	1	1	1	1	1
66	Agyei et al	1	0	0	0	0	NA	NA	NA	NA	NA	0	1	0	0
67	Otieno & Povey	0	1	0	0	0	NA	NA	NA	NA	NA	1	0	0	1
68	Kazima et al	0	1	1	1	1	NA	NA	NA	1	1	1	1	1	1
69	Opanga D	0	1	0	0	0	NA	NA	NA	1	1	0	1	0	1
70	Bowden et al	0	1	1	1	1	1	1	0	1	1	0	1	0	1
71	Kuchah & Milligan	0	1	1	1	1	NA	NA	NA	NA	NA	1	1	1	1
72	Adler & Essien	0	1	1	1	1	1	1	1	1	1	1	1	1	1
73	Aqil	1	0	0	0	0	0	0	0	1	1	1	0	0	0
74	Azrou	0	1	1	1	1	1	1	1	1	1	1	1	1	1
75	Bowden et al	0	1	1	1	1	NA	NA	NA	NA	NA	1	1	1	1
76	Essien et al	0	1	1	1	1	NA	NA	NA	NA	NA	1	1	1	1
77	Longwe et al	0	1	1	1	1	0	1	0	1	1	1	1	1	1
78	Robertson & Graven	0	1	1	1	1	NA	NA	NA	1	1	1	1	1	1
79	Shuukwanyama, et al	0	1	1	1	1	0	0	0	1	1	0	1	0	1
80	Venkat & Morrison	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Total		11	64	49	48	46	29	30	22	46	52	49	66	43	41

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