THE ROLE OF LANGUAGE IN THE TEACHING AND LEARNING OF EARLY GRADE MATHEMATICS

Focus on the Interdependence between Language and Mathematics in the Early Grades
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Address
Postcode and town, country
T +49 61 96 79-0
F +49 61 96 79-11 15
E info@giz.de
I www.giz.de

Authors:
Dr Anthony A Essien, Johannesburg
Dr Yasmin Sitabkhan, Washington D.C.

Design:
Diamond media GmbH, Neunkirchen-Seelscheid

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- Unlocking Talent through Technology: Improving Learning Outcomes of Primary School Children in Malawi (in partnership with onebillion and VSO Malawi); and
- South African Numeracy Chair (SANC) project at Rhodes

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LIST OF ACRONYMS/ABBREVIATIONS

LoLT Language of Learning and Teaching
LiEP Language in Education Policy
PRIMR Primary Reading and Math Program
RCT Randomised Control trial
SANC South African Numeracy Chair
SA South Africa
T&L Teaching and learning
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EXECUTIVE SUMMARY

The UNESCO report on the use of indigenous languages in education in 1953 (UNESCO, 1953) highlights and officially recognises the importance of the use of mother-tongue instruction. It was not until more than 20 years later, in a symposium sponsored by UNESCO in 1974, that the spotlight was cast on the relationship between language and mathematics, and more specifically, on the learning of mathematics in multilingual contexts (Phakeng, 2016). Since then, there has been increased attention to the role of language in the teaching and learning of mathematics.

The purpose of this report is twofold. First, a literature review provides an overview of the research on the role of language in early grade mathematics teaching and learning in developing countries. Second, the authors examined the extent to which mathematics intervention programmes in three developing countries – Kenya, Malawi, South Africa – recognise and attend to language issues in the design and implementation of their programmes. To do this, the report is structured around the following questions:

1. What research exists on the role of language (and/or multilingualism) in the teaching and learning of mathematics in the early grades in developing countries?

2. How has this body of research contributed to our understanding of the role of language in the teaching and learning of mathematics in the early grades? What research gaps exist in this area?

3. To what extent do early grade mathematics curriculum / language in education policies, pedagogy and teacher education in developing countries take into account the role of language in early grade mathematics education, as reported in existing research?

4. To what extent do early grade mathematics interventions in Kenya, Malawi, and South Africa account for the role of language in early grade mathematics education?

5. What recommendations for policy makers, donors, and implementing organizations can be made (based on the literature review and findings from early grade interventions programmes) to inform curriculum development, pedagogy and teacher education?

The three countries involved in this study were selected because they have similar characteristics: teaching and learning occur in a multilingual context; their Language in Education Policies (LiEP) are similar; and most of the students in these countries learn mathematics in English – a language which is not their first or home language.

Findings

The following findings emerged from the study:

• The literature review points to the importance of the role of language in the teaching of mathematics in the early years. Mathematics is learned through language, and involves reading, writing, listening, and discussing, all of which are heavily language-based activities. Despite this importance, many children in low-income countries learn mathematics in a second language without adequate acknowledgement of the role of language.

• Existing literature highlights the importance of i) providing ample teacher training for effective instruction in multilingual mathematics classrooms, ii) the use of effective instructional strategies such as code switching (the practice of using two or more languages present in the classroom by either the teacher or the students or both), and iii) providing materials and instruction in the home language where possible.

• Reviews of the LiEP in the three target countries reveal that the implementation of language sensitive mathematics teaching and learning is fraught
with difficulties due to a number of factors: indigenous languages are oftentimes not yet fully developed as academic languages, teachers may not be trained in the same language as the students, and there is difficulty in providing learning materials in a large number of languages.

- Reviews of different intervention programmes shed light on the constraints that exist in teaching children in their home languages, while also emphasising the importance of language in mathematics.

- In South Africa, the South African Numeracy Chair (SANC) project at Rhodes University provides an in-depth look at how teachers can be trained for teaching in a multilingual context like South Africa, and how research into the improvement of numeracy in schools can inform teacher development. The project points to the importance of specifically addressing multilingual issues in mathematics teacher training. However, the project is small, and the scale-up may involve challenges.

- In Malawi, the project Unlocking Talent through Technology: Improving Learning Outcomes of Primary School Children (in partnership with onebillion and VSO Malawi) (subsequently referred to as: Unlocking Talent/onebillion) uses technology in an innovative way to provide individual instruction to all students in their home language. As the project is scaled up, it will be interesting to understand how the role of language in mathematics changes with the addition of new languages, and the challenges and potential solutions that will arise.

- In Kenya, the Primary Maths and Reading Program (PRIMR) project was a large-scale project focused on scale-up and sustainability. Because of this, it was difficult to provide instructional materials in multiple languages. This project illustrates some common constraints in large programmes, but also offers glimpses of promising practices through the use of code switching and other instructional strategies.

- The reviews of the literature and intervention programmes point to a scarcity of research about the role of language in early grade mathematics in developing countries. The scarcity was found across all areas: teacher training, materials development, and pedagogical practices. In addition, there is a dearth of longitudinal research into the impact of language in the teaching and learning of mathematics in the early grades.

**Recommendations regarding policy**

Students should be given the opportunity to study in their first language up to Grade 6 before transitioning to English where possible. This would give them the cognitive academic advantage in their home/first language before they switch to English. In addition, LiEP should promote the development of conceptual knowledge and understanding in mathematics. However, it is equally important to recognize constraints to teaching all students in their first language which may not be a possibility in many contexts (e.g., multilingual classrooms, classrooms where teachers and students do not speak the same language, classrooms where materials are only available in the language of instruction). In these cases, there should be strong pedagogy to support students learning mathematics in a second language, including teacher training in second language strategies.

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1 For the ease of reading, the term ‘Grade’ is used consistently across countries. Whereas the terms for different grade levels vary across countries (Class, Standards, Grade), the numeric levels are the same.
Recommendations for teacher education

One of the findings is that there is no study on best practices in the training of teachers in the use of both home language and language of teaching and learning in early mathematics education. Doing this would go a long way in improving the practice of code switching, which is the predominant pedagogic practice in multilingual early grade mathematics classrooms. Teacher education needs to pay special attention to code switching, as it has the potential for improving mathematics understanding if appropriately used.

Given the nature of multilingualism and the LiEP in all three countries, a second and related recommendation is for pre-service teachers to receive some training in the use of the indigenous language(s) to teach mathematics where possible. For example, one method of training teachers that would need further research relates to the conduct of pre-service and in-service trainings in indigenous languages. In addition, pre-service classrooms that themselves reflect language diversity can be used as a model for how best to teach mathematics when there are multiple languages in use in the classroom.

Recommendations regarding pedagogical practices

There is a need for more research that explores best practices in multilingual mathematics classrooms in the early grades from low-income countries. Research points to the importance of code switching, but more research is needed to understand when to code switch, as well as how materials can support teachers in using code switching to benefit all students. In addition, more research is needed on other pedagogical practices that may support students, such as the use of everyday language for mathematics.
SECTION ONE
INTRODUCTION
Studies on mathematics achievement in developing countries have shown that learners’ performances in mathematics are often well below expectations. For example, research commissioned by GIZ (2014) on teaching numeracy in pre-school and early grades in low-income countries noted concerns of low performance in numeracy in primary schools across many countries in Africa, Asia and Latin America. In many countries, e.g. in South Africa, underachievement in high stakes mathematics examinations has been found to be more prevalent amongst students who use English language less frequently at home (Simkins in Taylor, Muller, & Vinjevold, 2003). Similarly Taylor and Coetzee (2013) examined the performance of primary school children (Grades 1-6) with African home language compared to their English and Afrikaans home language counterparts. The authors concluded that there is a significant disadvantage when instructions are received in English rather than the home language of the child. More specifically, research into the state of primary education in South Africa has indicated that students (in some poorly resourced schools) fall behind by as much as 2-3 years below their actual grade by the time they are in Grade 6 (see Hartley, 2007; Spaull & Kotze, 2015; Mohohlwane & Taylor, 2015; Human, Van der Walt, Posthuma, 2015). Early grade assessment in mathematics in Malawi showed student performance well below the curriculum expectations, with a vast majority of students only able to answer basic elementary questions (USAID, MTPDS, 2011). A similar trend in low performance in mathematics has been reported in Kenyan schools (see for example, Nyabuto & Njoroge, 2014). Language factors have been found to be an important factor in this low attainment (see Jordaan, 2011).

Although there are many ways to improve the quality of the teaching and learning (T&L) of mathematics, one area that is often understudied in early schooling is the role of language and how language impacts the T&L of mathematics. Research on the impact of language in the T&L of mathematics has largely focused attention on high schools. In contrast, evidence on the role of language in primary schools (especially the early grades) is scant. This is surprising as it is during the early grades that up to 40 percent of students globally study in a language which is not their first or home language, as noted in the Policy Paper 24 (Global Education Monitoring Report, 2016). These early grades are crucial for building the foundations for mathematics.

In addition, limited attention has yet been paid to research on teacher education in terms of the role that language plays in the T&L of early grade mathematics. Furthermore, with respect to teacher education, the importance of equipping teachers with the understanding and the skills they need to be able to deal with and support students who grapple with language-related problems are not yet sufficiently addressed.

But what role does language play in academic attainment in general and in the teaching and learning of mathematics specifically? In Section 3 of this report, we review relevant existing evidence and engage in a discussion about the role of language in mathematics. Suffice it to say for now that research has long acknowledged the centrality of the role of language in the teaching and learning of mathematics. Various mathematics education research (Clarkson, 1991, 1992; Cummins, 1979; Pimm, 1981, 1987; Pimm & Keynes, 1994) on the interplay between language and mathematics point to the intricate link between language competence and mathematical aptitude. Any teaching or learning of mathematics involves activities of reading, writing, listening and discussing (Pimm,
For any teacher, language provides a medium by which concepts and procedures are introduced and conveyed, through which texts and problems are read and solved, and by which mathematics achievement is measured. Also, studies have shown that dialogic discourse which involves exploratory talk in which a variation of viewpoints are explored, and where participants can agree or disagree, challenge, question, appeal to reason and allow self-correction where necessary is cognitively beneficial to students (Fisher, 2013).

The present study serves a dual purpose: first, it provides a literature review of existing research on the role of language in early grade mathematics T&L in developing countries and research gaps are identified; second, the study examines to what extent intervention programmes in three developing countries – Kenya, Malawi, South Africa – recognize and attend to language-related issues in the design and implementation of their programmes. It is with the above in mind that the study is informed by the following key questions:

1. What research exists on the role of language (and/or multilingualism) in the teaching and learning of mathematics in the early grades in developing countries?
2. How has this body of research contributed to our understanding of the role of language in the teaching and learning of mathematics in the early grades? What gaps exist in research in this area?

3. To what extent do early grade mathematics curriculum / LiEP, pedagogy and teacher education in developing countries take into account the role of language in early grade mathematics education, as reported in existing research?

4. To what extent do early grade mathematics interventions in the three identified countries account for the role of language in early grade mathematics education?

5. What recommendations for policy makers, donors, and implementing organizations can be made (based on the literature and early grade interventions programmes) to inform curriculum development, pedagogy and teacher education?

In answering the guiding questions above, a thematic focus was placed on the following areas – curriculum / LiEP, pedagogic practices and teacher education (see Figure 1):

Engaging with these three thematic areas entailed the analysis of curriculum documents and research into pedagogic practices within each of these countries, focusing on early grade mathematics; analysis of literature on how teacher education in each of the countries attends to the dynamics of T&L mathematics in multilingual contexts; and finally, analysis of how intervention programmes in each of the focus countries attend to the role of language in the T&L of mathematics.

Structure of the report

The report is sub-divided into five sections, whereby this first section is introductory.

Section 2 deals with data collection procedures. Here we provide justification for the choice of the three countries involved in the study and give an indication of the scope of the reviewed literature. Section 3 provides an overview of key findings from existing research on the role of language in T&L in mathematics. Section 4 focusses more specifically on the three identified focus countries – Kenya, Malawi, South Africa – and findings from the review of existing literature and curriculum documents (mainly LiEP) are presented. Furthermore, Section 4 also summarizes how current early mathematics programmes account for the role of language in the T&L of mathematics. Section 5 concludes with recommendations based on the findings from the present study.

Figure 1: Overview of the study

- Role of language in Mathematics
- Literature Review
- Early Grade Intervention Programmes
- Curriculum
- Pedagogic Practices
- Teacher Education

Engaging with these three thematic areas entailed the analysis of curriculum documents and research into pedagogic practices within each of these countries, focusing on early grade mathematics; analysis of literature on how teacher education in each of the countries attends to the dynamics of T&L mathematics in multilingual contexts; and finally, analysis of how intervention programmes in each of the focus countries attend to the role of language in the T&L of mathematics.
SECTION TWO

CHOICE OF COUNTRIES AND DATA COLLECTION PROCEDURES
Choice of the countries in focus

Why Kenya, South Africa, and Malawi? The three countries reflect a regional focus which was chosen in order to center the attention on a continent that is characterized by high linguistic diversity. As noted in the Policy Paper 24 (Global Education Monitoring Report, 2016), T&L in a foreign language in which students are not (yet) proficient occurs mainly in areas where linguistic diversity is greatest such as in sub-Saharan Africa, Asia and the Pacific. All of the selected countries are multilingual: In South Africa, there are eleven official languages. In Malawi, there are just over sixteen languages, including Chichewa, Tumbuka, Lomwe, Yao, and English (Chilora, 2000; Kaphesi, 2001). Kenya has approximately 40 distinct languages with a total of twenty-two mother tongues identified for use in the Kenyan education system (Bunyi, 1997; Mwaniki, 2014). The nature of multilingualism in these three countries is discussed in more detail in the next chapter.

Another commonality that these three countries share is the hegemony of English as a language of T&L, although many students have a home language other than English. Yet, the LiEPs in the three countries recommend that learning be done in the home language in the first years of schooling before switching to English.

Lastly, countries were chosen where information on early mathematics intervention programmes was available and accessible. One early mathematics programme was examined per country, whereby all of these programmes aim at improving the T&L of early grades.

Selection of papers for review

In providing answers to the guiding questions for this report, we first reviewed literature relevant to the issue of language in the T&L of mathematics. We first looked at published research in peer-reviewed mathematics and general education journals in each of the countries. Then, we sourced relevant data from unpublished reports and other journal articles, including documents on teacher training, pedagogical frameworks and curricula in each of the countries, as well as monitoring and evaluation reports written by field implementers. We further examined documents explaining various early mathematics programmes implemented in the countries in focus. Book chapters were also considered as much as they related to the role of language in the T&L of mathematics in the early grades of the particular country. In all of the above, we restricted data sourcing to research and reports published in the last 10 years, 2006 to 2016.

Table 1 provides a summary of the total number of reviewed outputs on the role of language in the T&L of mathematics in the early grades in each of the focus countries. We identified over 200 outputs dealing with curriculum polices, pedagogic practices and teacher education at primary school level, however only those that directly related to language-related aspects in the T&L of mathematics were considered.

<table>
<thead>
<tr>
<th></th>
<th>Journal papers</th>
<th>Unpublished report</th>
<th>Book Chapter</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>10</td>
<td>7</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Malawi</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Kenya</td>
<td>13</td>
<td>4</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>TOTAL</td>
<td>35</td>
<td>12</td>
<td>3</td>
<td>50</td>
</tr>
</tbody>
</table>

As table 1 shows, a total of 50 outputs were found, with 70 percent of these being journal articles. One major limitation in the selection of outputs for this study was that of accessibility on the internet. This means that information materials which focused on intervention programmes in any of the three focus countries but which were not published either in a journal or book chapter were systematically excluded from the study. We also could not include articles and especially book chapters which were not downloadable.
Selection of intervention programmes

In addition to a review of the literature, we also conducted interviews with key informants who were running intervention programmes in the focus countries that were directed towards improving T&L of mathematics in the early grades. In South Africa, we interviewed a key informant from the SANC project at Rhodes University – a project that has been running for the last five years and which has now been funded for the next five years. In Malawi, we interviewed a key informant from the programme Unlocking Talent/one-billion which uses tablets to improve the T&L of mathematics in Grades 1 and 2. In Kenya, we interviewed a key informant from the PRIMR project, an early reading and mathematics programme that aims to improve the quality of learning in the early primary years.

The selection of the intervention programmes above was determined by several factors. First, we looked for diversity in the scale of the programme (i.e., small scale versus large scale) as well as the scope of the program (e.g., technology-based, focus on teacher training, focus on materials development). We chose projects that were all implemented by different organizations. Finally, we needed access to key informants in the programmes. We limited our interviews to one intervention programme per country.
SECTION THREE
THE ROLE OF LANGUAGE IN THE TEACHING AND LEARNING OF MATHEMATICS: A RESEARCH PERSPECTIVE
There are several issues that are inextricably intertwined in contexts where multilingualism is the norm (rather than an exception) in early mathematics classrooms. First, students learn mathematics in a language which is not their first / home language. Second, students come to school with varying degrees of language proficiency in the Language of Learning and Teaching (LoLT), whereby some are not proficient at all in the LoLT. In what follows, we engage with these language-related issues through a review of the general research on the role of language in the teaching and learning mathematics. It is important to note that although these issues inform the recommendations in Section 5, we do not engage specifically with the body of literature from the three focal countries until Section 4.

The importance of an adequate proficiency level in the language of instruction and the specificities of academic language

The most significant work done in the area of bilingualism and cognition is that of Cummins (1978, in Lyon, 1996) in the development of the threshold theory. The threshold theory attempted to explain why some studies reported bilingual students as cognitively disadvantaged compared to monolingual learners, whereas others reported bilingual learners as cognitively advantaged compared to their monolingual counterpart (Lyon, 1996). The threshold theory is therefore one theoretical position that explains negative and positive findings as far as bilingual education is concerned. It stipulates that "those aspects of bilingualism which might positively influence cognitive growth are unlikely to come into effect until the child has attained a certain minimum or threshold level of competence in his second language" (Cummins, 1978, in Lyon, 1996: 57). Distinguishing two levels of threshold, Cummins postulates that the lower threshold is sufficient to avoid the negative cognitive and academic effects of bilingualism (in the semilingualism zone), but the higher threshold is necessary to reap the positive benefits of bilingualism (Cummins, 1979). He argues that once a student has attained a certain level of linguistic competence in his / her second or third language, positive cognitive results can occur (Baker, 1988), and the further the child progresses towards proficient bilingualism, "the greater the probability of cognitive advantages" (Baker, 1988: 175). Cummins (1979), in explaining research studies which demonstrated a negative relationship between bilingualism and cognitive processes, suggests that a key reason for such a relationship is an inadequate level of language proficiency in the bilingual subjects (that is, bilinguals who fall below the lower threshold level). Cummins (1979) also suggested that cognitively beneficial bilingualism can be achieved only when the students' first language is adequately developed.

Several studies (Clarkson, 1992; Dawe, 1983; Heugh, 2002) have tested Cummin's Threshold theory and cast a spotlight on the importance of language, and more specifically, the importance of proficiency in students' home language as a key factor in the T&L of mathematics. Elaborating on these findings, Nieman (2006) points out that the fact that a student understands the teacher in class and is able, with ease, to read in the language of teaching and learning, does not presuppose that such a student will understand academic texts as easily and write fluently. Based on previous research findings (Cummins, 1984), Nieman (2006) distinguishes between 'basic interpersonal communicative skills' (BICS) and 'cognitive academic language proficiency' (CALP). Whereas BICS denotes language proficiency in a social situation and is characterised by interpersonal interaction, CALP positions itself as the second level of additional language proficiency.

This second level of language proficiency is what is needed, if learners are to read and understand scientific reports, tasks or academic assignments in general (Nieman, 2006). Cummins argues, based on his and other studies, that it takes approximately two years of exposure for students learning in a second language to attain conversational fluency (BICS) in the second language. On the contrary, it takes five to seven years of exposure for the same students to approach first language-appropriate grade norms in academic
aspects of the second language (CALP). Similarly, Fillmore (1982, in Cuevas, 1984) points out that second language learning becomes an even more difficult process when part of the language first encountered is that in textbooks and the classroom.

Research findings that relate more specifically to language competencies in mathematics education shed further light on the central role of language therein. Research conducted by Halai (2004) in two multilingual classrooms in Pakistan concluded that in a multilingual classroom, how students make sense of the mathematics is determined by (1) how they understand the particular usage and structure of the language; (2) how the use of everyday language shapes mathematics learning; (3) how students express mathematical thinking in their own language; and finally, (4) how language is used in the textbooks in contrast to how the teacher uses language. Students whose first / home language is equivalent to the language of instruction are familiar with the linguistic structures they encounter in the mathematics classroom (Barwell, 2002; Cuevas, 1984). Research has shown that this is not the case for students whose home language is not equivalent to the LoLT (Adler, 2001; Barwell, 1998; Barwell, Barton, & Setati, 2007; Clarkson, 1991; Gorgorio & Planas, 2001; Halai, 2004; Setati, 2002, 2005a, 2005b; Setati & Adler, 2000; Wallace & Goodman, 1989).

Mathematics teachers dealing with students whose first language is not the language of instruction thus need to be conscious of the complex process not only of learning a second language (Cuevas, 1984), but also the even more complex process of learning (mathematics) in a second language. Similarly, Barwell (2009) argues that in multilingual classrooms of learners whose home language is not the LoLT and who are not yet proficient in the LoLT, teachers are faced with the triple challenge of striking a balance between attention to mathematics, attention to English (LoLT) and attention to mathematical language. The question arises, how teachers do currently respond to these realities and how current practices could be improved. The following section will shed further light on the question on current realities and learning conditions for the teaching and learning of mathematics in South Africa, Kenya, and Malawi.

3 Mercer (2000) is quick to add that even learners studying in their first language have much to learn about how that language is used in the classroom as an educational medium.
SECTION FOUR
THE CONTEXT OF SCHOOLING: LANGUAGE IN EARLY GRADE MATHEMATICS IN SOUTH AFRICA, KENYA, MALAWI
This section focuses on the context of schooling in Africa, Kenya, and Malawi in light of country-specific literature related to curriculum / LiEP, teacher education / professional development and pedagogic practices. For each of these focal areas, the research outputs were coded according to the themes they aligned with. Some articles focused on more than one theme, and were thus coded twice or thrice. Hence, it is important to note that the sum total is not necessarily equivalent to the total number of research outputs that were analysed (see tables in subsequent paragraphs). The section starts off by examining the curriculum / LiEPs in the three focus countries. The second part of Section 4 focuses on different intervention programmes that are aimed at improving the T&L of mathematics in South Africa, Kenya, and Malawi.

Theme 1: The context of schooling – curriculum / LiEP

Our use of the term ‘language in education policy’ or language policy (LiEP) resonates with how this term is used by Trudell and Piper (2014) to mean “a set of principles formulated and legally established by the state, intended to guide language use particularly in the public domain” (p. 5).

The most frequent topic of research carried out between 2006 and 2016 is on the impact of the LiEP in each of the countries as shown in Table 4.1. This demonstrates that the debate about mother tongue instruction is virulent in all three countries. Furthermore, the table demonstrates that most of the studies rely on qualitative research designs, whereas only very few use a quantitative or mixed-method design. Similarly, longitudinal studies that would track students learning trajectories over time are very rare.

South Africa

As Broeder, Extra & Maartens (2002) rightly pointed out, South Africa presents a complex and interesting picture of multilingualism. This is due not only to its political history of apartheid, but also to the distinctive nature of its multilingualism. Of the 11 officially recognised languages in South Africa, nine are indigenous African languages. These African languages can be grouped into two major groups based on their linguistic distance\(^5\): The Sotho languages and the Nguni languages. The Sotho languages comprise South Sesotho, Sepedi, Setswana, while the Nguni languages are isiZulu, isiXhosa, siSwati and isiNdebele. There is mutual intelligibility between the languages in each of these groups (this is not the case with the remaining two indigenous African languages: Tshivenda and Tsonga). Because of this mutual intelligibility of languages, other indigenous languages are easily learned.

English and Afrikaans were the only two official languages during the period of apartheid (1948–1994) despite the presence of African languages. Learners were required to take both English and Afrikaans as subjects for the first 12 years of schooling. But the kind of Eng-

| Table 4.1. Number of papers published under curriculum / LiEP |
|-----------------|----------------|----------------|-----------------|----------------|
| Country         | Qualitative   | Quantitative  | Mixed–Method    | Longitudinal   |
| Kenya           | 8             | 1              | 1               | 0              | 10             |
| Malawi          | 10            | 0              | 0               | 1              | 11             |
| South Africa    | 9             | 2              | 0               | 1              | 11\(^4\)       |
| **TOTAL**       | **27**        | **3**          | **1**           | **2**          | **12**         |

\(^4\) The longitudinal study used a quantitative approach. Hence, the total output is 11 instead of 12

\(^5\) Linguistic distance is taken as the extent to which two or more languages differ from each other/one another with regards to, amongst myriads of other characteristics, vocabulary, grammar, written form, structure and semantic aspects of the language and their status.
lish that was taught was “presented as a complexly structured and grammar oriented subject, only taught for the purposes of tracking black people towards low-skills forms of labour” (Cele, 2001, p. 188). During this period of segregation, mother-tongue schooling for Africans was favoured for quite different reasons than those advanced by educationists and researchers like Cummins (1979) or Clarkson (1991, 1992). Mother-tongue instruction was used as a tool to oppress and marginalise the blacks, and this contributed in no small measure to giving mother-tongue education (and to a large extent, the use of African languages) a negative connotation because of the tendency to equate it with the “ravages Bantu education” (Alexander, 2012, p. 5; see also Essien, 2013). The apartheid legacy also affected teacher education in that pre-service teachers whose first language was not the LoLT were inadequately prepared for the provision of emancipatory education and teachers with low proficiency in English often taught in the local languages (Cele, 2001).

The unbanning of liberation movements in the early 1990's saw full recognition of the rich multilingual nature of South Africa and the adoption in 1996 of 11 official languages (see Setati, 2002). Accordingly, in 1997, the apartheid LiEP with its unequal language proficiency demands for learners was replaced with a new policy based on non-discriminatory language use (Heugh, 2002, Setati, 2002) which calls for the promotion of multilingualism in the education sector through the use of languages (DoE, 2002). Today’s policy recognises the multilingual nature of South African classrooms and the importance of using language as a tool for students’ attainment of their full potential to participate and contribute to the intellectual growth at school and in the society at large (DoE, 2003, pp. 29–30). The LiEP thereby advocates that learners choose their LoLT and that School Governing Bodies need to stipulate how the school would promote multilingualism in the school.

For South Africa, existing research on curriculum policies focuses mainly on the language preference of learners and teachers in mathematics education. Research by Setati (2008) has shown that given the hegemony of English, the freedom given by the LiEP for schools to choose their LoLT is indeed a chimera as it does not exist in reality. Setati (Setati, 2002, pp. 7-8) notes,

> Hence, even though the LiEP and the Constitution of South Africa provide learners with the theoretical opportunity to learn in any of the 11 official languages of their choice, research has shown that due to economic, social, political and ideological factors, most students at early and higher grade levels prefer to learn mathematics in English, which for most is not their first or home language (see Setati, 2008). Similarly, teachers at early and higher grade levels prefer to teach mathematics in English (Setati, 2008, Essien et al, 2015). Mati (2004) specifies that, what has been unofficially adopted by most (public) schools is the use of mother-tongue as the LoLT in the foundation phase (Grade 0-3). The shift in most schools from using learners’ first / home language as the LoLT to using English happens at the grade 4. Yet, in some schools where there is a high demand for English by stakeholders, learners are gradually introduced to English as early as Grade 1. The dominant language of the learners and Afrikaans are then taught as subjects. As noted by Hennings (2013), this policy assumes that young children who learn mathematics concepts in an African language would be able to translate these concepts and operations to English by the time they enter fourth grade. This is not a straightforward enterprise. Focussing on teachers’ preferences, Essien et al. (2015), in a study on the
use and efficacy of multilingual materials developed for use in early grade mathematics classrooms, noted that teachers preferred to use English in teaching (if they were given a choice) for three reasons: first they felt that the mathematics register in the materials provided was not always adequate for their purpose; second, they felt that the translations were long; and third, they felt that because the training was in English it made sense for them to teach in the language in which they had been trained. This is contrary to recommendations to promote mother-tongue education in the early grades (ZENEX, 2007).

Kenya

A parallel can be drawn with Kenya on a number of the issues discussed above. Kenya has a LiEP which advocates for the use of home language in the first three years of schooling. More specifically, the policy requires that the language of the “catchment area” should be used in linguistically homogeneous areas for the first three years of formal schooling; while for schools in linguistically heterogeneous neighbourhoods, the national language (Kiswahili) or English should be used for the first three years of schooling (Mwaniki, 2014). Similar to South Africa, in situations where the first three years of schooling are in the home / first language, a switch to English is made in Grade 4.

A key focus of research in Kenya around curriculum policies are implementation difficulties of the LiEP. Our review of literature revealed that little progress has been made in implementing the LiEP (see for example, Nyaga & Anthonissen, 2012). Another dominant trend in Kenya as far as policy and curriculum are concerned, similar to South Africa, relates to language preference. Kioko’s (2013) research study shows that because parents fear that ‘too many’ languages in the school system would negatively impact their children’s learning, parents do not favour mother-tongue as the LoLT in the early grades. This position also resonates with research carried out by Trudell and Piper (2014) whose study into the implementation of the Kenyan language policy in the classroom found that children in Grades 1–3 were mainly receiving instruction in English from the start of primary school. As Oduor (2010) notes, “a major weakness of the educational policy in Kenya is that none of the indigenous languages, apart from Kishwahili, is taught as a subject” (p. 86). Research on the Kenyan context also shows inconsistency and variation in the implementation of the LiEP in schools (Jones, 2014; Mbaka, Peter & Karuri, 2013; Oduor, 2015; Ogechi, 2009). For example, research by Oduor (2015) on how primary teachers implemented the LiEP in the classrooms indicated that the use of mother–tongue was left at the teachers’ discretion. Whereas some teach mathematics using their mother–tongue from the early grades to the upper grades, others (mostly in the urban areas) did
not use mother tongue at all in teaching. They used solely English whereas Kiswahili was being taught as a subject. Another group used both English and Kiswahili to teach in the early grades.

Furthermore, research on LiEP in Kenya engages with the effects that the language policy could have – if implemented effectively – on the T&L in the early grades (Abd-Kadir & Hardman, 2007; Gacheche, 2010; Hardman et al., 2009). For example, Abd-Kadir and Hardman (2007) argue that due to the disparity that often exists between the English language proficiency level of teachers and students, the use of mother-tongue in the classes could greatly enhance student participation in mathematics.

**Malawi**

The situation in Malawi is similar to that of both Kenya and South Africa in terms of the LiEP. Malawi is home to a number of indigenous languages – just over 16 of them (Chilora, 2000; Kaphesi, 2001). As noted by Halai and Karuku (2013), LiEP are informed by factors such as the “pressure to conform to hegemonic ideologies of colonial language as the dominant language of globalization” (p. 24). Even though over 16 indigenous languages are used in Malawi, English plays a significant role in both the school and teacher education contexts (Chitera, 2012). Whereas English is regarded as the official language, Chichewa, which is spoken by more than half the population, is the national language. The current LiEP, developed in 1996, states that students in Grades 1–4 should be taught in their mother tongues (Kamwendo, 2008; Chiuye & Moyo, 2008). The Malawi Primary Education Curriculum and Assessment Framework (Ministry of Education, Science and Technology, 2006), amongst others, also advocates for pedagogic strategies such as brainstorming, discussions, story-telling or debate – activities which are heavily language-dependent.

A key focus of research in Malawi around curriculum and language policies is research on how the school language policy impacts the T&L of mathematics in the early grades. Research about teaching students in their home language in Malawi points to difficulties in implementing indigenous languages as the LoLT. Kaphesi (2001) conducted a study on how the use of home language influences the quality of mathematics that is learnt in 69 primary schools (with 2208 students and 188 teachers). Based on test scores in mathematics, the findings from this study suggest that there was an interaction between students’ home language and the home language of the teachers. For example, students whose home language was Chiyao and who were taught by teachers whose home language was Chichewa made lower gains in the learning of mathematics. The study goes on to recommend that teachers need to teach students who share the same home language as the teachers. Kazima’s (2008) study on the ways in which mother-tongue policies and mathematical terminology impact the T&L of mathematics indicates that much of Chichewa terms are borrowed (in the sense of transliteration) from English and do not have meaning in Chichewa. However, the author indicated that teachers regarded this transliteration of terms to be effective while instructing mathematics in multilingual classrooms.
Theme 2:
The context of schooling – teacher education / professional development

Across the three countries, as Table 4.2 below depicts, there was very limited research into how teachers are trained to teach early grade mathematics in multilingual contexts. Similar to existing research on LiEP, research designs rarely drew on quantitative or mixed-methods and no longitudinal study could be identified.

South Africa
With respect to the role of language in teachers' qualifications, the South African Minimum Requirements for Teacher Education Qualification (DHET, 2011, pp. 15-16) stipulates that to qualify as a teacher, one needs to “be proficient in the use of at least one official language as a language of learning and teaching (LoLT), and partially proficient [that is, have conversational proficiency] in at least one other official language (including South African Sign Language).”

Although this policy states what teachers should know, it does not address how teachers should harness or draw on students’ linguistic resources. In addition, it does not state how teachers are to be trained in order for them to effectively exploit the linguistic knowledge of students for effective learning of mathematics to take place in multilingual settings. In South Africa, three research studies were identified to deal with teacher education. These research studies are very divergent in focus. One of these studies records the experiences of certain practitioners involved in school improvement with a particular focus on systemic improvement test programmes implemented in two Provinces in South Africa (see JET, 2013). The key finding in this study of which a focus was improving teacher quality and teacher development was that sustainable school improvement would thrive if school interventions programmes aim to change the schools and the district within which they operate. Another study within this theme focuses on practices teacher educators are exposed to during their training (see Essien, Chitera and Planas, 2016). Findings from this study revealed that while teacher educators are aware of the complexity of teaching and learning in linguistically diverse context, this awareness is not reflected in their practice. The third study simply provides a summary of what research has been carried out (by the Centre for Development and Enterprise) on teachers, teaching and learner performance in mathematics (see CDE, 2014). Based on the review of research, the study indicated that both pre-service and in-service teacher education need rethinking and redesigning in order to turn around current practices in mathematics teaching across schools in South Africa. To do this, the CDE suggests (among others) that the development of the subject content knowledge and pedagogical content knowledge of student teachers should be an integral part of all initial teacher education programmes. Also, it is suggested that qualifying teachers need be proficient in the LoLT at a conceptual level especially in mathematics. To this end, the CDE recommends that teachers who teach mathematics should be qualified to teach the subject at the grade level they teach (that is, at the appropriate grade level for which they were trained). CDE also suggests that qualifying teachers should be trained

<table>
<thead>
<tr>
<th>Country</th>
<th>Qualitative</th>
<th>Quantitative</th>
<th>Mixed–Method</th>
<th>Longitudinal</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Malawi</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>South Africa</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>10</strong></td>
<td><strong>1</strong></td>
<td><strong>2</strong></td>
<td><strong>0</strong></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>
to be able to communicate in one of the African indigenous languages and that continuous professional teacher development interventions aimed at improving mathematics teachers’ teaching should include a strong language component as this is the language that is used in most school from Grade 4.

Kenya
The Kenyan primary teacher training curriculum which was revised in 2004 mandates that student teachers study five compulsory subjects: English, Kiswahili, professional studies, physical education and information and communication technology (ICT). In a way, this is a recognition of the fact that Kiswahili as an indigenous language is important. But as Ogechi (2009) notes, this only gives prominence to one indigenous language over the other indigenous languages in Kenya. Furthermore, at the end of their qualification, novice teachers are posted to any part of Kenya regardless of whether or not these teachers are proficient in the language of the ‘catchment area’ (Nyaga & Anthonissen, 2012). Such teachers grapple not only with the content of teaching mathematics, but also with teaching it in a language they are not fluent in, and in a language that they did not use as the LoLT in the teacher training. As a result, these teachers end up using Kiswahili to teach early graders who themselves are neither proficient in Kiswahili nor in English.

With regards to research on teacher education in Kenya, the key focus in the literature is teacher preparation in the teaching of early reading and mathematics (Bunyi, Wangia, Magoma, & Limboro, 2013; Pryor, Akyeampong, Westbrook, & Lussier, 2012), and mother-tongue discourses in relation to primary education and the quota system in Kenya (Mwaniki, 2014). However, none of these studies directly focused on teacher preparation as it concerns the dynamics of language and mathematics in the teacher preparation.

Malawi
With regards to teacher education in Malawi, existing evidence dealt with discourse practices in mathematics teacher education of early grade (and beyond) pre-service teachers. Research by Chitera (2011) found that the discourse practices in teacher education classrooms “are embedded in conventional practices of multilingual classrooms – the act of production that centers on the mathematics teacher educators as being professional and experts” (p. 1463). Chitera’s (2011) research also found that the way in which mathematics is taught at the teacher training institutions reflects the traditional focus on acquisition of facts, mastery of procedures and technical skills. This pedagogic style is then transferred to classroom situations when the pre-service teachers eventually become qualified early grade teachers. This is because, as Chitera (2011b) notes in a different paper, not much has been done “to train math-
ematics teachers on how to use local languages in the classroom” (p. 231). In fact, in her research on LiEP, Chitera (2012) notes that even though lower primary education (Grades 1–4) is carried out in the indigenous languages, primary teacher education on the other hand is carried out in English (similar to most teacher training programmes in South Africa and Kenya). Chitera (2012) argues that the language practices in teacher training college classrooms do not reflect the language practices in primary classrooms as mathematics teacher educators tend to comply very strictly with the official LiEP policy. In fact, Chitera (2012) noted in her research study that while on the one hand teacher educators admit that using a home language in teacher education is important, on the other hand, pre-service teachers were not allowed to use indigenous languages to communicate their mathematical thinking in class as this was seen as violating the official language policy. This inconsistency between the language of study and the language of instruction was also noted in an earlier study by Kaphesi (2003) involving eight mathematics teachers in Grades 1–4. With respect to the transition phase from mother tongue to English as a language of T&L, we did not find any literature on how teachers are trained to manage this transition.

Theme 3:
The context of schooling – pedagogic / language practices

Table 4.3 below shows the number of studies we found that deal with language practices in early grade mathematics. Again, most studies drew on qualitative designs and quantitative and longitudinal studies are rare or not existent.

The studies or reports (on intervention programmes) on this theme 1) suggest a way forward for the T&L of mathematics in the early grades, and 2) describe practices which the authors believe to be best practices for teaching mathematics in the early grades.

South Africa

In her report about setting a strong foundation in literacy and numeracy for Grades 1–6, Hartley (2007) identifies that one limitation of current pedagogic practices is the lack of teaching and learning materials that allow children to learn to read, write and solve mathematical problems in their home language in the early grades. Consequently, Hartley (2007) suggests that teaching and learning materials need to be developed for this purpose.

Table 4.3. Number of papers published under pedagogic practices

<table>
<thead>
<tr>
<th>Country</th>
<th>Qualitative</th>
<th>Quantitative</th>
<th>Mixed-Meth.</th>
<th>Longitudinal</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Malawi</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>South Africa</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>TOTAL</td>
<td>16</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>
One of the ways in which this suggestion has been taken up by researchers is in the use of multiple languages (whereby students have access to mathematics materials and questions in their home language and English simultaneously) as a possible strategy to mediate teaching and learning.

For example, research by Botes and Mji (2010) used a learner companion which comprised mathematics terms and expressions in English and in some South African indigenous languages to evaluate whether the mathematics performance of 2,348 Grades 4-6 students would be positively impacted by the introduction of a multilingual visual explanatory mathematics learner companion. 20 schools as well as 20 educators from the treatment schools were involved in the study. The results show a positive correlation between the use of the learner companion and performance in mathematics. In a similar study, the Gauteng Primary Language and Mathematics Strategy (GPLMS) implemented between 2011 and 2015, provided T&L materials in all the South African indigenous home languages alongside English. In their evaluation of the use and efficacy of the GPLMS materials, Essien et al. (2015) noted that some teachers indicated that the technical mathematical terms in Home Language were terms that they had not encountered in spite of being proficient in the respective language.

A related issue to the ‘technical’ nature of some indigenous language definitions was the complaint from some early grade teachers that some translations in the materials were much longer than their English versions, with this making teaching mathematics in the home language more complex. For example, the English version of the question: Use near doubles to add in order to encourage learners to participate more freely in the class and as a means of enabling learners to harness their first (home) language as a learning resource. However, whereas practices such as code switching have been extensively researched in South Africa, research has been silent on how this phenomenon occurs in early grade mathematics, especially given that the mathematics register in the indigenous languages is not yet fully developed. In fact, given that the transition from the use of indigenous language to English happens in Grade 4, it is to be expected that at this level, there would be much code switching in the classroom. The question of how teachers manage this transition and what language practices are used in Grade 4 has not been a focus of the research outputs we examined. Yet, there was only one study with a direct focus on language practices in the transition class. Furthermore, as previously noted, evidence is lacking that identifies how teachers are trained to effectively exploit the linguistic knowledge of students for effective learning of mathematics.

Kenya
In Kenya, research on pedagogic / language practices in primary classrooms highlights the importance of focusing on the practice of dialogic pedagogy, a term most authors refer to as a learner-centered approach to teaching (Abd-Kadir & Hardman, 2007; Gacheche, 2010; Hardman et al., 2009, Hardman, Ackers, Abrishamian, & O’Sullivan, 2011; Metto & Makewa, 2014). Several factors are cited by these authors as being responsible for the dominance of a teacher-centered approach, amongst others, the quality of pre-service training, the lack of opportunity for learners to use their home language for exploratory talk; poor teacher pedagogic practices such as the lack of questioning practices that provoke extended dialogue; teaching through the medium of English which is not learners’ first / home language; and finally, the teacher’s home language is, in some instances, different from the students’ home language. Code switching (the practice of using two or more languages present in the classroom by either the teacher or the students or both) has been cited by research in Kenya (Abd-Kadir & Hardman, 2007; Gacheche, 2010) as one of the lan-
guage practices used by teachers in many early grade mathematics classrooms for a number of reasons. Research on the practice of code switching revealed that it occurs because students are still learning the LoLT, and also because there is a lack of mathematical vocabulary in many indigenous Kenyan languages.

Malawi
In Malawi, a study by Kaphesi (2003) investigated how mathematics teachers in Grades 1-4 implement the language in education policy in Malawi in their classrooms. Through observations and focus groups, Kaphesi found that the LiEP frequently created tensions for teachers while teaching mathematics. The policy in Malawi states that children should learn in local languages (including Chichewa) during the first four years of primary schooling. Tensions arose, though, due to inconsistency and ambiguity about how this should be carried out. The author describes a case where a teacher had a teacher’s guide in English, a pupil’s textbook in Chichewa, and was asked to plan the lesson in English but deliver the lesson in Chichewa. The study also revealed that a common pedagogic practice that teachers used to deal with these tensions was code switching between English and Chichewa. Code switching allowed teachers to flexibly use language in mathematics instruction to support student learning of concepts. With respect to the transition phase from the home language to English in which code-switching can be expected to be most prominent, our literature search identified no studies on how teachers and learners in Malawi manage this transition, and what language practices are used in class.

Gaps in the literature on the role of language in early grade mathematics

For the timeframe selected for our review, i.e. research published between 2006 to 2016, we did not find enough research that focuses directly on language practices of teachers in early grade mathematics and how these practices impact the teaching and learning of mathematics. Generally, as indicated earlier, there is paucity of research in three core areas: longitudinal research on the role of language in early grade mathematics; on how teachers are trained and how teachers should be trained to teach mathematics in the early grades in multilingual classrooms; and quantitative studies on the role of language in the T&L of mathematics in the three countries.

With respect to teacher training, Chekaraou (2009) provides relevant insights into the role of multilingualism during teachers’ pre-service training from research in Niger. The author (Chekaraou, 2009) investigated teachers’ appropriation of a bilingual educational reform policy in two schools in Niger, and found that pre-service teachers who were enculturated into the intricacies of using different languages to teach during their pre-service training found it easier to accommodate different languages in multilingual classrooms. On the other hand, pre-service teachers who were not trained for bilingual classrooms and were not exposed to ways in which to accommodate the different languages in a multilingual classroom found it difficult to accommodate different languages when they began to teach in schools.
In addition to the aforementioned limitations of existing research, the following country-specific research gaps should be noted. For the case of South Africa, we found no study which specifically examined the role of language in the academic attainment of those Afrikaans students and English first language students who continue with their home language all through schooling and thus who never have to switch to a different language in Grade 4, and how these students compare with African students who have to switch in Grade 4. For the case of Kenya, a major gap in the literature is the fact that we found no research that is concerned with the development of Kiswahili as an academic language and how experiences of such a development (if any) can be used to inform the development of other indigenous Kenyan languages. Similarly, for the case of Malawi, an under-emphasis in the literature concerns the development of the indigenous languages as languages of scholarship, and how teachers and students deal with mathematics terminologies in the early grades that are not present in the indigenous languages. In this vein, Moyo (2001, in Chiuye & Moyo, 2008) argues that beyond the elevation in 1996 of the other 6 languages (Chitumbuka, Chitonga, Chiyao, Chilomwe, Chisena and kihongo), little else seems to have been done regarding the use of these indigenous languages as LoLT in primary education.

**Intervention programmes in the focus countries**

As indicated earlier, informants from three early grade mathematics intervention programmes were interviewed on the role language plays in their projects. The Primary Reading and Math Programme (PRIMR) in Kenya provided training, classroom materials, and coaching for teachers in Grades 1-2 in reading and mathematics. Classroom materials included teacher guides and student workbooks that were “sequenced with a focus on ensuring efficiency, providing opportunities to reinforce concepts, helping students see the connections between concepts, and teaching multiple strategies” (Piper et al., 2016, p. 4). The results of the intervention point to modest gains on procedural measures of mathematics learning in Grades 1 and 2, and conceptual gains in Grade 2.

Unlocking Talent / onebillion in Malawi provided a mathematics App on tablets for students in Grades 1 and 2 and provided in-service and pre-service teacher training. The App consisted of math activities based on the Malawian National Primary Curriculum, such as counting and number recognition (Pitchford, 2015). Pitchford (2015) conducted a randomised control trial (RCT) design where students were put into three groups: one using the math App on tablets for 30 minutes a day, another using the tablet but with non-specific software, and a third group without any use of the tablet. Results showed that students that used the math App made significant gains in mathematics outcomes compared with the other two groups.

The South African Numeracy Chair (SANC) established a partnership between researchers and teachers to improve mathematical teaching and learning. In this paper, we focused on one element that entailed the development of classroom materials and in-service teacher training for primary school teachers.

The goals of each of these projects were to improve learning outcomes for students in mathematics through materials in classrooms and training for teachers. However, the approaches they used were different. The table below provides a detailed summary of the programmes. Following the table, we discuss the differing approaches of the three programmes with regard to the themes articulated above: language in education and curriculum policies, teacher training / professional development, and pedagogic / language practices.

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6 The article by Chiuye and Moyo (2008: p136) only indicates that “the paucity of learning and teaching materials in the […] indigenous languages that were elevated to official status in 1996, as well as poor teacher training, have been the greatest challenge of using these languages as media of instruction in Malawi.”
Table 4.4. Table summarising the intervention programmes in the three countries

<table>
<thead>
<tr>
<th></th>
<th>Primary Reading and Math program (PRIMR) (Kenya)</th>
<th>Unlocking Talent / onebillion (Malawi)</th>
<th>South African Numeracy Chair (SANC) project at Rhodes (South Africa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overarching objective(s) of the intervention programme</td>
<td>• To improve numeracy outcomes among Grade 1 and Grade 2 children in Kenya;</td>
<td>• Unlocking Talent, in partnership with onebillion and VSO, aims to improve the quality of primary school education for children in Malawi. The project focuses on marginalised groups across all education districts; Grade 1 and 2 learners, in-service and pre-service teachers, TTC lecturers, primary education advisors, out-of-school youths and children with special needs will benefit directly.</td>
<td>• To improve the quality of teaching of in-service teachers at the primary school level</td>
</tr>
<tr>
<td></td>
<td>• To improve quality of learning in early primary years in Kenya;</td>
<td>• Using an iPad app software, a key objective is to deliver transformational learning to one billion children through the development of mathematical skills in the early grades.</td>
<td>• To improve learner performance in primary schools as a result of quality teaching and learning</td>
</tr>
<tr>
<td></td>
<td>• To apply innovative, data-based instructional improvement methods to increase students’ fundamental skills in reading and mathematics</td>
<td></td>
<td>• To research into sustainable and practical solutions to the challenges of improving numeracy in schools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Using an iPad app software, a key objective is to deliver transformational learning to one billion children through the development of mathematical skills in the early grades.</td>
<td>• Provide leadership in numeracy education and increase dialogue around solutions for the mathematics education crisis</td>
</tr>
<tr>
<td>2. Participants</td>
<td>• 316,000 Pupils;</td>
<td>• 30,000 Pupils</td>
<td>• 14 researchers;</td>
</tr>
<tr>
<td></td>
<td>• Teachers were trained and provided with lesson guides (then trained to develop their own lesson plan), and the pupils were provided with workbooks</td>
<td>• 450 Teachers</td>
<td>• over 14 teachers (Grade 0 to 6);</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Learners (Grades 3 and 4); and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Parents</td>
</tr>
<tr>
<td>3. Duration of the programme</td>
<td>Started in 2012 and ended in 2015.</td>
<td>onebillion indicated that they do not have a fixed timeframe for their project</td>
<td>5 years in Phase 1; now in the second phase for another 5 years</td>
</tr>
<tr>
<td>4. Funding of programme</td>
<td>Funded by USAID</td>
<td>Funded by the Royal Norwegian Embassy and the Scottish Government</td>
<td>Funded privately and by the Department of Science and Technology</td>
</tr>
</tbody>
</table>
5. **How programme effectiveness is evaluated by stakeholders**

The evaluation consisted of an RCT design using a treatment and control group. Randomly selected students from all treatment and control schools (both public and non-formal schools) were assessed via administration of a combined Early Grade Reading Assessment (EGRA) and Early Grade Mathematics Assessment (EGMA), at three time points: baseline, midterm, and endline. Math assessments were administered in either English or Kiswahili, using the language the child was most comfortable with.

Results were reported as gains on conceptual and procedural indices. There was a statistically significant effect on the procedural index for Grades 1 and 2, and an effect on the conceptual index for Grade 2. These effects were concentrated in the non-formal schools, where teachers tended to be less trained and experienced. This suggests that it was easier to impact mathematics learning outcomes with less experienced teachers.

6. **Approximate percentage of students not fluent in LoLT**

Fluency level in English in the first grade is very low (10%) and improves as the pupils move to higher grades (to about 30% in grade 2 and 30% in grade 3).

7. **Teachers fluency in LoLT**

Teachers are mostly fluent in English.
<table>
<thead>
<tr>
<th>Programme</th>
<th>Language in which programme / materials is / are embedded</th>
<th>Specific component addressing language use in classrooms</th>
<th>Other language related challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Reading and Math program (PRIMR) (Kenya)</td>
<td>The programme was in English even though the LiEP stipulates that the language of the environment should be used in the first 3 years of study. Hence, in-service training was in English and the children were also taught in English. All the materials are in English.</td>
<td>The same children who underwent the treatment in mathematics, were also given English language treatment. The app is designed to allow children to learn basic mathematical skills in the local language.</td>
<td>Fluency level of the pupils in English; some children struggle to understand the teacher in English. To help these pupils, teachers code-switch. The challenge is more acute in Grade 1.</td>
</tr>
<tr>
<td>Unlocking Talent / onebillion (Malawi)</td>
<td>The app is designed to be in the home language of the child. Currently in Malawi, the app is in Chichewa. Future plans for scale-up include a detailed process whereby the app is translated into the home language of the child (for other students for whom Chichewa is not the home language).</td>
<td>The app is designed to allow children to learn basic mathematical skills in the local language.</td>
<td>When scaling up, it may be difficult to find accurate local translations for rare languages.</td>
</tr>
<tr>
<td>South African Numeracy Chair (SANC) project at Rhodes (South Africa)</td>
<td>• English is the language of the project, but members of the community (teachers, researchers, students) can speak in whatever language they want. • Materials (homework book, fraction cards, etc.) are in Afrikaans and IsiXhosa. • Three languages are prominent: English, Africans and IsiXhosa.</td>
<td>Teacher development course, with some sessions focusing on language and mathematics. All sessions in the course also focused on the development of mathematical language by drawing on learners' home language(s) and everyday language as a resource, developing the mathematical concepts in whichever language the teacher was teaching in.</td>
<td>• Unsophisticated register in IsiXhosa. • Response to lack of fluency of teachers and students in Grade 4 is that they are encouraged to code-switch.</td>
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</table>
### 11. Possibility of scale-up and sustainability

<table>
<thead>
<tr>
<th>Primary Reading and Math program (PRIMR) (Kenya)</th>
<th>Unlocking Talent / one billion (Malawi)</th>
<th>South African Numeracy Chair (SANC) project at Rhodes (South Africa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Programme ended in 2015, but has now been taken up by the government and is in a scale-up process. The new project is called PRIDE project.</td>
<td>• The hope is for a scale up to reach all 5,300 primary schools in Malawi. It is currently in 68 schools.</td>
<td>One cannot scale up a project that is locally informed. Instead, what can be shared are resources/materials, and strategies/methods. The project would need to be adapted/recontextualised, if, for instance, it is supposed to be scaled to a national level and many aspects need to be considered. The work is therefore adaptable to the national level.</td>
</tr>
<tr>
<td>• For the scale-up to work, the materials must be in English due to the high cost that would be involved in sticking to the LiEP in Kenya, which would entail developing materials in multiple languages.</td>
<td>• In terms of sustainability: The project works with local researchers in Malawi, hence with the local community and there are already local volunteers whose job it is to maintain the technology. The local researchers on the long run should take ownership of the project at some point.</td>
<td></td>
</tr>
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</table>

### 12. Challenges for scale-up and sustainability

| • Sustainability of the project would be a primary challenge. Pupils write in the workbook. So, this means printing and reprinting the book each year which is not cost effective (for 4.2 million children) | • Translating the app in all local languages that exist in the population. While they have a detailed process for translation including local language speakers, it may be challenging for rare languages. | A challenge to sustainability is funding. |
| • Payment issues for the coaches: The government does not have a policy of electronic transfer of funds through MPESA to the coaches. Other means of payment would engender corruption. | • Getting a teaching force that is both confident and competent at using the technology | |
| | • Training the teachers to understand how to use the data collected on individual learners and how to act on the data appropriately | |
| | • Also infrastructural challenges and maintaining the devices (replacement, updating and repairs) | |
| | • the need to obtain more funding for infrastructure (building the learning centres), hardware (obtaining the tablets), and evaluation research, if Malawi are going to be able to roll out to 5000+ more primary schools | |
Curriculum / language in education policies

The Unlocking Talent / onebillion project and the SANC project both made efforts to implement the LiEP of the country. In Malawi, the app is provided in the home language (Chichewa) of the students that used it. In South Africa, the project makes efforts to train teachers and provide materials in the home language of students. In Kenya, the PRIMR project produced materials and trained teachers in English, but recognized that students needed support, and code switching was used.

Teacher training / professional development

While teacher training was a central component of all three projects, the role of language in teaching mathematics was not dealt with explicitly on the PRIMR and Unlocking Talent / onebillion project. This is in contrast to the SANC project, which conducted a teacher training course where specific sessions were focused on the role of language in mathematics. The course supported teaching in developing mathematical language by drawing on the home language of students, and by using everyday language as a resource in teaching the formal mathematics.

Pedagogic / language practices

Consistent with the literature, the most common instructional practice for teaching mathematics in multilingual classrooms was code-switching. In this way, teachers were able to help students access mathematical content in a language they understood. Both the PRIMR project and the SANC project reported use of code switching by teachers. In addition, the SANC project went one step further, by providing teachers with other strategies for dealing with multilingual classrooms, including using students’ everyday language as a resource (for example, helping students bridge between the language they use to describe shapes, such as “ball” and the mathematical language “sphere”). The SANC project explicitly taught pedagogic strategies to teachers, whereas the PRIMR project did not explicitly instruct teachers in their use.

Overall, the findings from these intervention programmes highlight three key points. First, the programmes focus on the role of language in mathematics to differing degrees. In PRIMR, there is an awareness of the fact that mathematics proficiency is developed simultaneously with English language proficiency. Nevertheless, the low language proficiency of the students in Grades 1-2 is a key problem as some students struggle to understand the teachers in English. In Malawi, the intervention programme uses the Chichewa version of the mathematics App in the teaching of mathematics knowledge, as all of their target population speak Chichewa as their home language. However, the design of the programme includes the use of the App in the local language of the child, which will become more salient as the programme is scaled up. The use of technology provides a unique opportunity to provide students with mathematics instruction in their home language in multilingual classrooms, and may have potential to be scaled-up without the constraints that other projects may face. The SANC project was aware of the role of language in multilingual classrooms, as it explicitly provided teacher training on instructional strategies, as well as materials in several languages. In sum, only one program, the SANC, specifically addressed the role of language in mathematics.

A second key point is the value accorded to code-switching in the T&L of mathematics. Lack of fluency in the LoLT is cited as a key reason for code-switching in the PRIMR project while the lack of certain mathematics register in the home language is cited as one of the reasons which necessitates the use of code switching for the SANC project in South Africa.

A third key point concerns the constraints that each project faced, and how the role of language played into these constraints. The PRIMR and Unlocking Talent / onebillion project are each very large projects that focused on scale-up and sustainability. The PRIMR intervention was targeted to 316,000 students
and their teachers, and onebillion was targeted to 30,000 students and their teachers. At this scale, it would be very difficult to provide classroom materials in all home languages of students in countries that are as multilingual as Kenya and Malawi without the use of technology. Because the Malawi project has technology at its core, it presents an interesting case of using technology to allow children in multilingual classrooms to access content in their home language. As the project is scaled up in Malawi, it will be important to understand how classrooms function when children are using the App in different languages while the teacher is instructing in a possibly different language, and how teachers are trained to deal with these types of multilingual classrooms.

Other constraints may be that there is no guarantee that a teacher speaks the language of the students, in which case materials in the home language would not be useful unless they were designed to be used alone by the student, as in the case of Malawi.

In contrast, the SANC project targeted about 14 teachers and also had 14 researchers. Because of this, the project was able to explore innovative methods for teachers to support students in multilingual classrooms. This research is important, and more of this type of research should be done to build up a base of knowledge of which strategies support students the best. In addition, research should explore how these methods can be altered to be scalable.

The role of language in mathematics teaching should not be ignored. Research needs to be conducted on the most efficient strategies to support students that do not speak the language of T&L, including how to train teachers on code switching and other strategies, how materials may be developed to support students, and how technology can best be integrated into existing instructional programmes.
SECTION FIVE
CONCLUSIONS AND RECOMMENDATIONS
This study highlighted the role of language in the teaching and learning of mathematics in the early years. Mathematics is learned through language, and involves reading, writing, listening, and discussing, all of which are heavily language-based activities. Despite this importance, many children in low-income/developing countries learn mathematics in a second language without an acknowledgement of the role of language.

What does the literature and our review of intervention programmes tell us about the best ways to support students that are learning mathematics in a second language, and where are the gaps in our knowledge?

First, the literature points to the importance of giving students the opportunity to study in the first language before transitioning to the official language, as also highlighted in Policy Paper 24 (Global Education Monitoring Report, 2016). This opportunity would give them the cognitive academic language proficiency in their first language and ensure that they are firmly entrenched in this language before switching to studying in English. The cognitive benefits of attaining proficiency in both the first language and an additional language have been corroborated in many research studies carried out in different countries.

Second, the research highlights the challenges in multilingual classrooms. When students learn mathematics in a language other than their home language, there is both code switching (between home language and language of T&L) and register switching (between language and mathematical language). The know-how of being able to engage with students using certain practices in multilingual classrooms, therefore, is more complex and differs to a certain degree from non-multilingual settings.

Third, the literature demonstrates that when teachers are given opportunities to practice teaching mathematics in other languages, and practice code switching, they are better prepared to teach in multilingual classrooms (Chekaraou, 2009). It can be argued, as does Essien (2014), that it cannot be assumed that pre-service teachers would develop competence in teaching in multilingual contexts by the mere fact that they sit in multilingual classes during their training programme. Therefore, pre-service instruction should explicitly target the role of language, and teachers should be given ample opportunities to practice instruction and to experience appropriate teaching methods (bearing in mind the LiEP) as part of their pre-service training.

The review of the different intervention programmes sheds light on the constraints that exist to teach children in their home languages. First, LiEP often are not implemented as intended. For example, although Kenya’s policy directs schools to teach in the language of the catchment area, this is difficult as materials are not available, and teachers may not be trained to teach in that particular language. It may be that LiEP need to be more nuanced and adapted to the realities of a given country. Another constraint of the intervention programmes relates to their respective scale. In countries such as Kenya, Malawi, and South Africa that are multilingual, teaching children in their home language may be possible with small interventions, such as the SANC project, or with technology, such as the Unlocking Talent/onebillion project, but difficult with larger projects, such as PRIMR. At large scale, it may not be easy to provide materials in all home languages without the use of technology. In addition, in some languages, mathematics vocabulary is not fully developed, making it even more difficult to accommodate students’ language needs.

The review of existing research and the examination of early math intervention programmes provide some clues as to how to support students in learning mathematics. The use of technology provides an opportunity to use local languages to teach mathematics in multilingual classrooms, but also presents challenges when trying to integrate the learning through technology in one language and classroom instruction in possibly a different language. Furthermore, it is important to identify the strategies that teachers can use to teach mathematics in multilingual classrooms,
if the students do not speak the language of T&L. The research points to the importance of code switching. Projects such as SANC are investigating other strategies that may be useful in early mathematics classrooms, such as drawing on everyday language. Yet, whereas there are some studies about code switching, there is a lack of research about how code switching occurs in instruction in the early primary years, and how this affects student learning. In addition, more research should be done to understand how the mathematics register is translated to other languages, and the most effective methods for teaching in other languages that may not have terms for specific mathematical vocabulary.

More generally, given the importance of the role of language in early mathematics, there is a dearth of literature on best practices for instruction in multilingual classrooms, methods for teacher training, how materials should be developed, and the effect of these on student learning outcomes. Both qualitative and quantitative studies should be conducted to understand, if students are learning, and how and why they are learning. Intervention programmes that target mathematics should pay explicit attention to language in materials development, instructional strategies, and teacher training components. They should gather data on best practices for increasing learning outcomes, and also create scalable models which take language into account.

Additional research should also be done to understand when the ideal time to transition languages is. In a country like South Africa, where a language like Afrikaans enjoys the status of being used as the LoLT for up to Grade 12 in some schools, research can provide an interesting opportunity to explore this idea. Research that tracks and compares the performance of students who use Afrikaans for primary education and switch to English at high school as compared to those who use Afrikaans for both primary and high school and only switch at University, would help provide useful insights and contribute to the debate regarding the appropriate time to switch from mother-tongue to English.
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