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Teaching and learning Mathematics in sub-Saharan Africa

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Teaching and Learning Mathematics in Sub-Saharan Africa: An Introduction to the Special Issue

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Abstract

Before the pandemic, it was estimated that globally six out of ten children and adolescents were not able to read or handle mathematics with proficiency by the time they are of age to complete primary education. That makes over 600 million children and teenagers (56%) whom we fail to teach the basic skills required for an independent adult life (UNESCO Institute for Statistics 2017). One of the areas where this educational challenge is largest is Sub-Saharan Africa. Not only is there a constant challenge to offer quality education for all, but due to population growth, an additional challenge is to train millions of new teachers for the growing school systems. This special issue paints a picture of the current state of mathematics learning and teaching in Sub-Saharan Africa with a focus on both teachers and students.

Keywords: Cross-cultural comparisons; mathematical achievement; mathematics education; mathematics learning; Sub-Saharan Africa; teacher education.

We, the editors of this special issue, began our joint academic journey in 2016 when we started as editors for an international handbook of mathematical learning difficulties published by Springer Nature (Fritz et al., 2019). The twist of this book was to have a special section about learning mathematics in different areas of the world. Our book had twelve interesting stories that offered us a quick glimpse into the surprisingly different circumstances in different regions and continents: how students study and learn mathematics, how teachers taught it and what the situation was in educational research. That motivated us to take a deeper look at different regions. First, we invited a group of distinguished researchers from Latin American countries to build a special issue on the local situation (Haase et al., 2020). For this second special issue, we invited a group of experts on maths learning and teaching who have studied broadly the situation in Sub-Saharan African countries. In Sub-Saharan African countries, there is an urgent need for scientific knowledge to guide the actions to improve the quality of education. This special issue is one of the efforts to provide this knowledge to a broader public. We were happy to find JALT to partner with us in this collaboration, which made producing this special issue possible.

In this special issue, we have articles that focus on information from different Sub-Saharan African countries (Botswana, Cameroon, Kenya, Malawi, Namibia, Tanzania, Uganda, Zambia, and Zimbabwe) as well as review papers covering issues like teacher education, low-free private schools, and using educational technologies. We hope the readers will find the authors' contribution to this special issue as interesting as we did.

Case: Sub-Saharan Africa (SSA)

Sub-Saharan Africa is, geographically, the area of the continent of Africa that lies south of the Saharan desert. From the perspective of the immense geographical, cultural and political diversity, the concept 'Sub-Saharan Africa' also could be considered absurd and misleading, if not a meaningless classificatory schema. It is mainly the colonialist history that connects the countries in this area. Otherwise, manifold would be the best word to describe this area that is more extensive than Europe and the USA together, divided into almost fifty countries with over 1.1 billion inhabitants. However, many international organisations, like the United Nations and World Bank, use this areal definition, allowing us to do the same.

With its abundant natural resources and increasing population, Africa has achieved remarkable growth in recent years. As a result, it draws the international community's

attention as 'the future global growth centre'. SSA has had remarkable economic and social development during the last two decades. According to the World Bank statistics (The World Bank, 2022a), the population of SSA increased from 665 million (2000) to 1.17 billion (2021). Urbanisation (currently 40% of the population) has followed a linear trend with a five per cent increase in a decade. Some of this growth is due to migration from rural areas. Still, most of it will occur due to natural increases in the urban population and the reclassification of rural areas as urban.

At the same time, the poverty headcount ratio (persons living below US$1.90/day) dropped from 58% to 38%, life expectancy rose from 50 to 62 years, and GDP per capita increased from $635 to $1,645. All imposing figures of growth, even though, at the same time, these numbers tell a story that there is an extensive amount of work left to improve the quality of living in this area.

Education for all

At the 1990 UNESCO World Conference on Education, the international community formulated the goal of providing all children access to quality primary education within ten years. In 2000, this goal was reaffirmed at the World Education Forum in Dakar with the 'Education For All' (EFA) initiative (26-28 April 2000, Dakar Framework for Education). In the following years, globally, the number of children attending school increased from 59% to 79%. Likewise, in SSA countries, the number of children in primary education has increased dramatically. During the last two decades, it has more than doubled from 90 to 184 million (The World Bank, 2020b), partly because of population growth and partly due to increased enrolment in school.

The percentage of children enrolled in school has continued to increase. In countries such as South Africa, Mauritius, Seychelles, and Kenya, it rose from 80 per cent in 1998 to nearly 99 per cent in 2018. However, some countries still struggle with offering education for all. It is especially true for conflict-depicted areas like Niger (66%), Mali (76%), Eritrea (68%), and especially Somalia (23%). There are also considerable differences in children's school enrolment between rural and urban areas in these countries.

In 2021, UNICEF estimated that 40 per cent of all school-aged children across Eastern and Southern Africa were not in school due to pre-pandemic levels of out-of-school children and COVID-19-induced closures. The pandemic almost doubled the number of out-of-school children. Since schools were closed, many students did not have the opportunity to receive instruction, feedback, or interact with their teachers. The situation was even worse when we add that there is minimal access to technologies such as radio, television, computers, and the internet in the poorest areas. These factors left many students unable to engage in remote learning. Even though governments in the SSA countries have focused on increasing digital education and literacy for teachers and students, widespread challenges remain. A South-African study from public schools (Van der Berg et al., 2022) showed that the pandemic has had a strong negative impact on schooling, with learning losses more significant in mathematics than in reading, and most extensive for the earliest grades.

At school and out-of-school

In 2018, UIS estimated that 20% of the primary school children in SSA were out-of-school. At lower secondary, that figure raised to 37%, and at upper secondary already to 58%, meaning that, in total, almost one-third of the school-aged children and adolescents were not at school. However, the variation between SSA countries is sizeable (see Figure 1).

Inoue et al. (2015) noted that several factors characterise out-of-school phenomena in SSA countries. The out-of-school problem prevails in low-income, Francophone, and fragile or conflict-affected countries. Living in rural areas, where distances are long, and the quality of the schools and education is lower, is also a central factor. Individual risk factors for out-of-school behaviour are low parental education, fewer working adults in the household, and gender, where girls are discouraged from pursuing education.

Early marriage is one thing that is detrimental to female youth's education (Inoue et al., 2015). So are safety, hygiene and sanitation issues, together with cultural and economic barriers. We cite the UNESCO Global Education Monitoring Report 2020: "Despite the proclaimed target of universal upper secondary completion by 2030, hardly any poor rural young women complete secondary school in at least 20 countries, most of them in sub-Saharan Africa" (UNESCO, 2020, Persistence of exclusion).

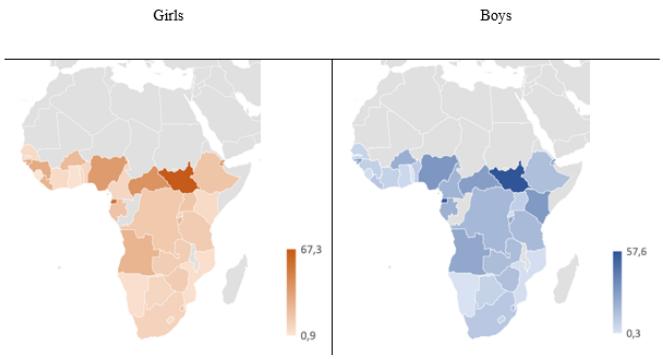

Figure 1. Out-of-school rates for girls and boys of primary school age (%). Note. The year of estimate varies from 2010 to 2021. Data source: UNESCO Institute of Statistics.

A long way to go

Despite the successful efforts to enrol all children in school, mathematics education in SSA is not up to the standard hoped in the mathematics education community. The EFA initiative not only envisioned that all children would receive schooling but that this education would be of high quality. Since the focus up to 2015 was primarily on the quantitative access of children to school, and significant progress has been made here, the 2030 Agenda of the international community will additionally focus on the quality of education.

The key reason for the focus change has been that despite the increased number of children at school, the students' performance levels have been low, and there has been only slow, if almost non-existing, development. For many students, the years at school have not been rewarded as learning. To illustrate this challenge in education in SSA countries, Table 1 shows the percentage of school children who have not attained even the basic skill levels in mathematics in SSA countries with some comparison countries from around the world.

Table 1. Percentage of students who do not reach the minimum threshold of learning.

Country	2000	2005	2010	2015
Sub-Saharan Africa				
Benin		76		
Botswana	49	51	45	36
Burkina Faso		63		
Burundi	48		52	
Cameroon		55		
Chad		75	56	
Comoros			58	
Cote d'Ivoire		75	63	
Democratic Republic of Congo			50	
Eswatini	43	48		
Gabon		65		
Gambia	63			
Ghana		63	54	
Kenya	28	41		
Lesotho	87	65		
Liberia	62			
Madagascar	60	42		
Malawi	96	71		
Mali	95			
Mauritius	35	30	26	
Mozambique	34	60		
Namibia	97	66		
Senegal	65	68		
Seychelles	39	42		
South Africa	71	67	56	47
Tanzania	45	43		
Togo	71		61	
Uganda	58	61		
Zambia	92	72		
Zanzibar	66	62		
Zimbabwe		52		
Comparison countries				
Argentina	40	35	34	29
Brazil	56	42	37	37
Canada	4	4	4	4
Egypt		36	36	36
Germany	16	11	9	8
Indonesia	38	35	37	40
Iran	31	34	33	27

Note. The minimum threshold is defined as low performance in the International Assessments (see Altinok, Angrist, & Patrinos, 2018). Datasource: (Our World in Data, 2022). Colour coding, dark yellow = above 75%, light yellow, above 50%, green = below 25%.

The data in Table 1 is from the The World Bank (Our World in Data, 2015) dataset. They have built globally comparable achievement outcomes for 163 countries and regions from 1965-2015 (Altinok et al., 2018). The estimates were constructed by linking standardised, psychometrically-robust international and regional achievement tests. Based on this data, we also calculated an average score for countries from the available data from the years 2000-2015 (Figure 2). In this analysis, twenty-seven out of the thirty lowest performing countries came from SSA. Only Botswana, Kenya and Mauritius reached the Latin American level. However, there seems to be a slow but systematic trend of improvement in learning outcomes. How severely pandemic affected this development in SSA, is still waiting for future analyses.

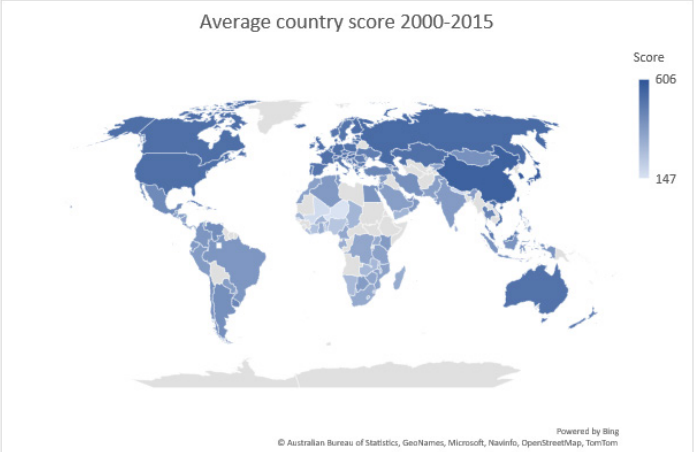

Figure 2. Average mathematics country score calculated from 2000-2015 assessments in 140 countries. Note: The scores from different assessments were transformed to the PISA scale (Mean 500, SD 100). Data source: (The World Bank, 2022b). See Appendix 1 for calculated values.

For some countries, the level of improvement in average scores may be underestimated. Learning outcomes can be expected to decline as the country approaches universal participation. It is because education systems must reach previously excluded and inherently disadvantaged populations where the education provision may be more difficult. Likewise, building quality education in extremely rural areas and circumstances is more demanding. Excluded populations may be poorer or marginalised, and these characteristics are, as known, important determinants of learning outcomes. It will take time for systems to adjust and provide quality education to more disadvantaged students (UIS, 2019).

For similar reasons, these numbers are overestimated for countries with high out-of-school rates. The international and local assessments are typically conducted at schools, not at homes. Conducting home-based surveys with representative samples is very expensive. Likewise, building measures that would reliably capture the thinking abilities of out-of-school youth might require different types of questions and tasks compared to those measures applicable to school children.

The challenge of teacher education

Modern societies depend on education. Societies and the labour markets favour those with higher education. The almost 90 million out-of-school youth, who comprise nearly half of all youth in Sub-Saharan Africa, will present a challenge for the development of the societies when they enter the labour market during the next decade. It has been estimated that another 40 million more youth will drop out and face an uncertain future without proper work and life skills required in the modern, technology- and automatization-driven societies.

However, at the heart of the solution for the educational challenge is high-quality teacher education supported by realistic mathematics curriculums combined with systematic and research-inspired educational methods. To reach the 2030 Education for All goals, an additional 15 million teachers are needed in SSA countries to offer schooling for the increasing number of pupils (ITFTE, 2021). High-quality teachers could create a snowball effect. Good basic education will produce workers with good skills for the labour markets as well as better teachers, and parents who value education and can support their children's academic development.

Political, economic and social stability is required for societies to invest in educational development. However, there are huge risks on the horizon that threaten this stability. For example, the effects of climate change will contest the stability in most of the countries. Therefore, a collaboration between the SSA countries and the global community is needed, not only in education but in all aspects of development.

Research is one of the activities that cross borders. Each new study published offers lessons for others to learn. One of the lessons we learned during this process of collating this special issue, was that there is a minimal number of over-the-borders studies done in SSA. When there is multicultural collaboration, they tend to be global-North-South projects. Cross-cultural studies within SSA are needed to understand better the mechanisms of learning because learning always happens in a particular environment and under certain circumstances. Even though the cognitive mechanisms of learning are the same in every person.

We hope this special issue will inspire more researchers to collaborate across borders to produce open-science and open-access-based publications on teaching and learning mathematics. Researchers, teachers, students and policymakers in the SSA countries need access to the research results. Publications presented behind the paywalls of journals are practically publications undone for most scholars and especially students in SSA universities. Therefore, we thank all our authors and the publisher for producing this open-access publication.

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Sub-Saharan teachers' conditions and circumstances: a review

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Keywords

Africa;
education;
professional development;
teacher training.

Abstract

This non-systematic review explores the state of public primary school teachers in Sub-Saharan Africa (SSA), including pre-service training, professional development, absenteeism and teaching and learning materials (TLMs). Overall, there are severe deficits in teacher content knowledge, pre- and in-service training, quality and quantity of available teaching and learning materials, and attendance. However, cases of resilience and effectiveness are also reported, based on qualitative data, which is also used to discuss decentralization and bottom-up approaches to educational challenges in resource-poor settings.

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Introduction

It is a truism that teachers are fundamental to the experience of schooling. While teachers do not tell the whole story of school achievement, it is unlikely for it to occur in the absence of proper teaching. However, guaranteeing qualified instruction comes with its own set of complex challenges, especially in resource-poor settings. Universal basic education is something that national governments in the global south were not prepared to provide in 1990 when the concept officially came about, and, in many cases, something they are not able to provide now. The explosive expansion of free schooling implied that the education provided would be of very low quality (Härma, 2021; World Bank, 2003; Birger & Craissati, 2009; Winkler & Sondergaard, 2008). One of the reasons is that the required human resources for teaching were not available and could not be quickly sourced overnight (Hansen, 1965; Indire & Hanson, 1971; UNESCO, 2019). Some countries did not have enough educated people who could become teachers if given the opportunity. Malawi, for instance, hired 20,000 new teachers, the overwhelming majority of high-school graduates with a quick two-and-a-half-week course as training. Countries ended up with a mixture of untrained, retired, and voluntary teachers (Birger & Craissati, 2009). The cohort of 500,000 teachers in 1970 reached almost 2.8 million in 2009 (UNESCO Institute for Statistics, 2011), and continues to grow in ever insufficient numbers. SSA has the world's highest and most consistent growth in school-aged population (World Bank, 2019a, 2019b). Qualified teachers would not only have to be arranged for, but this would need to be accomplished at a rate that could match the rising multitudes of children.

How qualified are the teachers?

National qualification requirements vary, making comparison frail. The proportion of qualified teachers can, however, indicate whether countries fulfill the requirements they have set for themselves. Average proportion of qualified primary teachers in SSA has decreased from around 85% in 2000 to 64% in 2015 (UNESCO, 2019) as schools continually hire unqualified teachers to fill their immediate needs at a lower cost. In the long term, poorly educated students grow up to be low-quality teachers, making the full picture rather bleak. Despite efforts to qualify teachers, many are functionally illiterate.

Some countries (e.g., Mauritius, Botswana, Kenya, Namibia, Uganda) reach 90% of qualified teachers; others (e.g., South Sudan, Benin, Angola, Senegal) are below 50%. Trends vary across and within countries, urban and rural areas, and time of entry into the profession. Data suggests positive developments: of 24 SSA countries, 17 had over 95% of newly recruited teachers meet national qualification standards (Nordstrum, 2015).

"Qualified teacher" does not mean quality teaching. Correlations between teacher training and student outcome in SSA are often very weak (e.g., Fehrler et al., 2009). Indicators such as years of experience and level of education are also unable to consistently predict teacher quality. Content knowledge is used as an indicator, as a teacher is expected to know what she or he teaches.

A study by Ngware and colleagues (2013) in urban informal settlements across six cities in Kenya showed that only 5% of teachers had no training whatsoever, and about half the sample had completed at least lower secondary education, with 22% having at least a bachelor's degree. But experience and qualification had little to do with the performance of their 3rd grade students in literacy and numeracy. In a test of math content knowledge, pedagogical knowledge and pedagogical content knowledge, teachers scored around 50%, with no difference between training and educational levels. Older and more experienced teachers scored less, though the difference was small. Another study from Kenya (Martin & Pimhidzai, 2013) showed that math and English teachers scored 73% and 56% in their respective subjects in a test intended for the lower-primary level; and all teachers scored a mean of 36% in pedagogical knowledge and skill. Training and seniority did not correlate with the teacher's performance.

In Nigeria, all 19,125 teachers in the state of Kwara, one of the nation's poorest, were tested on primary four material across four subjects (Johnson, 2008). To be considered "competent", a teacher was expected to score 80% or higher on all four subjects – which only seven people out of the sample managed to do. Many failed to score at all. Similar studies were conducted in southern Nigeria, with allegedly even worse results not made public (Härma, 2021).

Bold and colleagues (2017) used a sample of hundreds of schools across eight countries, representative of close to 40% of the SSA population. From each school, on average five teachers were tested. Instead of filling tests themselves, teachers were asked to mark mock student tests in language and mathematics from the lower primary. The math test also asked questions from upper primary school. 7% of teachers could reach the 80% mark in language, with the levels being uniformly low across countries. About 70% of math teachers reached the mark, but there was great variation, from 49% in Togo to 93% in Kenya. Along with the content knowledge for the subjects they taught, the research also probed pedagogical knowledge, how teachers monitor student progress and how much they apply their pedagogical knowledge in the classroom, based on direct observation. As in other tests, the threshold for being considered appropriate was getting 80% of the items right. 11% of teachers reached the threshold, in four countries, fewer than 5% did so.

Overall, most teachers in the SSA region are hardly qualified to offer a quality education. They struggle with the content knowledge they teach and with the skills necessary to translate this content knowledge into effective instruction and activities for their students. This is somewhat consistent throughout different levels of teacher education, pre-service training, and years of experience.

What education do teachers receive?

Many places have minimum qualification standards for teachers and established institutions to see them through, although a large cohort of teachers were and still are hired without meeting said standards to deal with the insurmountable demand. Teacher training usually requires at least lower secondary education, though it is not uncommon for people with upper secondary or post-secondary education to attend. Most are at the level of professional training. A few, such as in Mali and South Africa, require full-fledged bachelor's degrees and sometimes further study. The professional teacher training and degree programs can interact, allowing fast tracks and alternative options. Length is usually between one and three years. Kenya, Tanzania, and Uganda require one year; Senegal, Benin and Niger require two; and Zambia requires three, for instance. Fees and costs of attendance vary. Incentives, scholarships or special conditions may be available – e.g., In Uganda, teacher training is free, provided the teachers agree to teach in public schools. In other cases, like Burkina Faso, costs can be quite prohibitive (Nordstrum, 2015).

Increased teacher demand have pressured training institutions for output, leading to a decrease in quality which may already have been lacking. A report from Nigeria (Thomas, 2011) describes the strategic, operational, technical, political and attitudinal challenges at an educational college, where there were not even functional toilets. The three state colleges in Kwara were producing over 13,000 "qualified teachers" per year. This was actually above the demand, but reduced income from fees was seen as a threat to the colleges' position.

Additionally, the absence of qualified school leavers lowered entry requirements. The teaching career is not held in high regard. Teacher training absorbs school leavers who fail to pursue other paths of further education. In Lesotho, Eritrea, and The Gambia, passing mathematics was not a requirement for entry to teacher training or to teach mathematics (Mulkeen, 2009). Niger set a high standard by requiring a written thesis for training completion, which backfired with a national problem of forged teacher licenses (Nordstrum, 2015).

Teacher training mostly fails to compensate for trainees' lack of content knowledge. In Tanzania, only a fourth of mathematics and reading teachers received any pre- or in-service training focused on teaching their content area (Brombacher et al., 2013), with similar findings in Nigeria (RTI International, 2013) and Rwanda (deStefano et al., 2012). Ethiopia and Kenya show better figures for pre-service training, though teachers report a lack of in-service training (RTI International, 2012; Piper, 2010). When subject knowledge is present (e.g., Ghana's; Asare & Nti, 2014), instruction leans on more advanced material, assuming student teachers grasp basic school-level content, which they often do not.

Those teaching in teacher training also were inefficient. Across Eritrea, Malawi and Zambia (Mulkeen, 2009), tutors for primary teacher training colleges were picked based on academic qualifications. Most were former secondary teachers, some with no experience teaching primary. In The Gambia, 77% of tutors had never been primary teachers. In Zanzibar, the masters-level requirement kept the most experienced in primary school from becoming tutors.

To address the question of quality, some countries employ standardized tests, which need to be taken at some point during teacher training. In 2018, Zambia began to administer an aptitude test to teaching-job-hopefuls, with complete training as a prerequisite. If anything, this could bar illiterates from becoming teachers, which had, admittedly, happened before (Härma, 2021). A similar test was suggested in South Africa, facing stern objections from teachers' unions (My Broadband, 2018). In the early 2000s, Ghana introduced a test at the end of the first year of teacher training, which gatekept further study, guaranteeing that no time would be wasted on inadequate candidates (Akyeampong, 2003).

Once again, completing training does not mean that a teacher is qualified. National standards usually mean passing certain courses rather than being able to teach well. They frequently focus on education theory and pedagogical knowledge rather than practice in the school setting. In Tanzania, only a fourth of mathematics and reading teachers received any pre- or in-service training focused on their content area (Brombacher et al., 2013), with similar findings in Nigeria (RTI International, 2013) and Rwanda (deStefano et al., 2012). Ethiopia and Kenya show better figures for pre-service training, though teachers report a lack of in-service training (RTI International, 2012; Piper, 2010). Even if proper training is available and dedicated future teachers adhere well to it, in many cases, the material and curriculum may be lacking, for instance, focusing on an idealized classroom, very different from the extremely harsh conditions of many African schools. Teachers are then overwhelmed by real-world challenges and eventually succumb to the inertia of the system (Akyampong et al., 2013).

What is the reality and perspective of teacher professional development?

Making the teaching career attractive to candidates is an important component for growing and maintaining a qualified workforce. Teacher cohorts must contend not only with the growing school population, but also with teacher attrition and retirement. A teacher needs to continue to provide service to justify investment in quality via continuing education. Working conditions, career progression, salaries and alternative job opportunities are just some of the incentives that may lead to qualified and unqualified teachers both leaving the profession or moving to the private sector. In Uganda, the rise in the proportion of qualified teachers was due not only to qualifying new teachers, but also because many unqualified ones left the workforce. In Namibia, Mali, Angola and a handful of other countries, the rate of attrition is not sustainable (Nordstrum, 2015). In contrast, Kenya and Niger actually encourage senior teachers to retire in order to free up funds (Lengoiboni, 2014).

The incentives for the career of civil servant teacher can be quite high. In South Africa and Kenya, powerful teachers' unions negotiate allowances, maternal leave, and other

benefits (Kenya National Union of Teachers, 2007). Zambia offers daily subsistence allowance, 20% double shift allowance, 20% bonus for degree holders, permanent housing for 25% of primary teachers, and bonus for teachers working in rural areas, in addition to salaries (Mulkeen, 2009). SSA teachers' salaries may seem modest for those in developed nations, but when corrected for purchasing power, most countries offer at least four times the country's GDP per capita, with some reaching ten times the GDP per capita (UNESCO Institute for Statistics, 2011). Many teachers are relatively well-off for their country's standards of living, others not so much. Nigeria offers high salaries on paper, but teachers may receive them in part, late, or not at all. Some teachers rely on gifts from the students and parents for survival. The relatively high salaries and benefits are usually restrained to actualized civil servants, which often are a minority. Contract teachers' salaries and benefits are substantially less. The journey or opportunities for an unqualified contract teacher to become a certified and trained civil servant varies across countries and can be quite cumbersome.

National governments have frequently employed some form of "catching up" mechanism, so that teachers currently in exercise without proper certification may be trained without ceasing the provision of their services. Benin uses a combination of distance learning and face to face instruction over three years (Republic of Benin Ministry of Education, 2013). Ghana provides an alternative version of the traditional training, taking two years instead of three, as well as a distance learning four-year alternative (Ghana Education Service, 2012). The National teachers' institute of Nigeria provides distance learning courses for initial certification, upgraded qualifications, and professional development opportunities. Kenya made a six-moths distance learning program available in 2009, to deal with those already teaching and with the 18,000 unqualified personnel they hired that year (which led to strikes by unions). Uganda has a dedicated program for upgrading teaching certification into a full-fledged bachelor`s while in-service (Mulkeen, 2009). Mozambique, contrary to the norm, requires teachers to already be working via contract hiring to start their career before receiving pre-service training. Candidates then apply for a bureaucratic process which makes them probatory civil servants for two years and, afterwards, permanent civil servants. The process should take a minimum of four months, but many are left waiting for an indefinite amount of time. This is due to both government inefficiency and the high fees the teacher is expected to pay for registration (Beutel, 2011). Mozambique holds one of the highest proportions of uncertified teachers.

Both literature reviews and empirical research of "upgrade programs'' in Tanzania, Malawi and Nigeria (Krujier, 2010) found hurried introduction and implementation, and little regard for design, piloting and redesign. Training centers can be far from schools, making face-to-face tutoring and in-service mentoring hard to balance. Face-to-face tutoring was criticized as too crowded, short, and passive in some cases, with a lot of time spent on lectures. Content often focused heavily on participatory methods, not considering how appropriate it would be or whether it could be adapted to over-80-student-classrooms.

A plethora of SSA countries have plans for career progression and in-service training of teachers, beyond and complementary to certification and degrees. However, in practice, several of those initiatives are crippled by the lack of manpower and obstacles such as distant schools and high costs. As part of professional development, and also to improve and monitor quality in school, there are plans for counselors or inspectors to regularly visit schools and provide support and feedback (e.g. Benin, Mali, Uganda, Zambia, Niger). Becoming a counselor is sometimes a progression from the teaching cadre, and/or requires special degree qualifications.

In Burkina Faso, it requires three years of teaching experience, and becoming an instructor requires 6. Given the lack of teachers, counselors and inspectors are also drastically understaffed. In 2009, each inspector in Uganda was responsible for 771 teachers in 70 schools, in Zambia, for 181 teachers (Mulkeen, 2009). Many schools never see an inspector. And many would prefer not to. These counselors are often able to influence or determine the career progression of teachers, and thus, what was originally meant as a support and feedback mechanism threads a feeble line between helping and accessing, which can make teachers resistant to their interference. Mali has taken active measures to prevent this, changing inspectorates to "pedagogic advice centers", designed for advice support and training, instead of supervision (Lugaz & de Grawe, 2010). Kenya initially struggled to establish proper in-service training systems but was able to establish education resource centers which have tutors visit schools to discuss curricula and best practices. Benin organizes training around districts of four or five schools, and have an instructor focus on issues identified by school supervisors, while secondary teachers receive training with educators of the same subject on themes identified at the national level. Niger has ongoing training for directors, pedagogical supervisors, and inspectors on how to observe and give feedback to teachers (Antonowicz et al., 2010). Nigeria has student centers throughout the country, and professional development workshops through distance learning. Very active teachers' unions seek to bring teachers together for seminars and discussions.

Other places have more punctual interventions. Burkina Faso sought to provide regular seminars. Zambia offers in-service training offered through seminars and workshops by education colleges, though this is not regular or consistent, and is limited mostly to urban areas. Of note, however, are the Zambian dedicated programs for treatment, allowance, loans, and counseling to HIV positive teachers. The country, and the overall region, have a serious AIDS epidemic (UNAIDS, 2021). In Mozambique, teachers are required to participate in "pedagogical days" throughout the year, where they are provided additional instruction, receive help from their peers and share experiences. Short in-service training is available through teacher training colleges, but adherence is very low. Longer programs are available, but financial and time constraints are often overwhelming.

Though plans are made for professional development, they hardly come to fruition, especially in the rural countryside. Making them effective would be extremely costly, not only for arranging the qualified staff and keeping consistent

follow-ups to interventions. It would also require simple transportation, food and lodging costs for those involved; or the technology that would need to be arranged for to make distant learning a real possibility. In a 2012 Nigerian survey, 47% of teachers claimed to never have had the opportunity for in-service training (Nordstrum, 2015). The same was heard for 61% of Ethiopian (Piper, 2010) and 73% of Rwandan teachers (deStefano et al., 2012).

South Africa was more successful in providing training and tying this training into a cohesive career progression plan, which both makes teachers more accountable and offers incentives for desired results. The nation has regional, district and school-level monitoring and evaluation systems. The institution responsible for evaluating is independent from the school administration system and provides assessment reports of curriculum delivery and school management practices at the school, district, province and Department of Basic education levels (Nordstrum, 2015). All educators in public institutions must be registered in the South African council for educators.

There are "Continuing Professional Teacher Development" programs. These require registration and involve employers, non-governmental organizations (NGOs) and teachers' unions offering courses, programs and activities. Educators must receive a minimum number of professional development credits in three-year cycles (South African Council for Educators, 2013). Remuneration is based on the "Quality management System". Teachers receive ratings based on performance reviews conducted semi-annually. Teachers who meet expectations are reviewed as "good" and have their salary increased by 3% every two years. Teachers who surpass expectations are rated "outstanding" and have their salaries increased by 6% (South African Ministry of Basic Education, 2013). Teachers may also be promoted by performance, experience, and desire for leadership roles. After five years of teaching, they can qualify for head of department. After two years in the latter position, they may become deputy principals, and then, after two more years, a principal.

Other countries also have career or incentive plans, taking different factors into consideration, each with its trials and tribulations. Ghana's teaching career structure is based on professional accomplishment in the classroom, school management and district levels. When beginner teachers are promoted to licensed teachers (the immediate next level on the hierarchy), they are assigned a senior teacher to act as their mentor. Years of experience are still required for promotion, along with completion of in-service training, evaluations and interviews. Higher positions, such as head teacher and director, require evidence of management and leadership skills (Ghana Education Service, 2012). Kenya has a pathway through performance evaluation, order of merit lists and teacher proficiency courses. Mozambique teachers' salaries are determined by qualification, level of responsibility in leadership, and years of experience. Salaries vary greatly.

Incentives are not always maintained consistently. Governments may find themselves unable to promote or pay teachers once they have established requirements, as was the case in Kenya, Mozambique and probably elsewhere (Nordstrum, 2015). This is likely to demoralize and prevent any gains the incentive system might have provided. Other countries are altogether missing institutional incentives for high-quality teaching, with rewards delinked from performance and determined by qualifications and seniority (Bold et al., 2017; Nordstrum, 2015; Bruns et al., 2011).

The question of teacher absenteeism

Growing evidence indicates the enormous issue of teacher absenteeism in SSA (Read, 2015). Absenteeism could reflect difficulties and obstacles that make attendance less likely. Some take time for religious practices, like Friday prayers for Muslims. There is low extrinsic motivation, with no supervision, no payment, underpayment, or late payment. Unrecognized and unrewarded workers frequently feel overburdened and undervalued, contributing to absenteeism. Some miss classes to supplement income with other activities. Salaries, when available, may need to be collected at distant locations. In Nigeria and Zambia, rural schools can close for a week every month as teachers go back and forth to collect salaries (Nordstrum, 2015). The daily trip to school may require arduous commutes. The lack of school facilities, especially sanitation, toilets and potable water may discourage attendance.

Health conditions like malaria and AIDS are highly prevalent, and a sick teacher is in no condition to show up, even more so with the absence of healthcare facilities available in or close to the school. Maybe related to this are the frequent funeral attendances, also given as a reason for absenteeism. Lack of staff can divide teachers between multiple classrooms, implying attendance to only one at a time. Non-teaching responsibilities, such as cooking, can likewise limit classroom presence. Many countries do not recognize time spent outside the classroom, even if it's for lesson planning. Statutory working time is limited to teaching hours in Benin, Côte d'Ivorie, Djibouti, Guinea-Bissau, Guyana, Mali and Ekiti (Ekiti is a Nigerian state; UNESCO, 2017). Finally, in-service training can take up teaching time in an official capacity, especially if it requires travel. In Senegal, between 2007 and 2014, only 57% of planned school days were delivered. 15% of missing days were due to individual teacher absence, another 13% were due to (mostly teacher) strikes and 5% were due to teacher administrative duties (Niang, 2017). Some accountability interventions have increased student outcomes, but not teacher attendance, maybe because even with the will to, there is no sustainable way of attending. Notwithstanding, considering the data on teachers who show up but spend most of their time not teaching, low effort may also partially explain absenteeism.

Nearly 20% of teachers in Uganda were absent on any given day (Mulkeen, 2009); 25% were not in class when they were meant to be (Winkler & Sondergaard, 2008). A World Bank report on Uganda (Wane & Martin, 2013) found that 27% of teachers were absent, and of those present, a third were not teaching. 40% of classes received no teaching. A pupil in northern Uganda would receive 50 days of teaching in a year, 90 days less than in Kampala.

Kenyan teachers were absent from school 14% of the time but absent from class 47% of the time. Students received just over two hours of instruction a day. Older male teachers with seniority, higher education and training, and on permanent contracts were the most likely to be absent (Martin & Pimhidzai, 2013), suggesting that the lack of accountability and monitoring may be a contributing factor. Posting additional teachers to schools increased absenteeism (Duflo et al., 2015).

In Tanzania, in 2014, unannounced school visits found 14% of teachers absent despite being listed on the school roster (Wane & Martin, 2016). Students on average had just over two hours of contact with teachers (Fredriksen et al., 2015). The study by Bold and colleagues (2017), representing close to 40% of SSA population, found that across countries, a mean 44% of teachers were absent, either from the school or the classroom. This means a third of classrooms were unattended. Rates of absenteeism are remarkably stable over time. They remained about the same in Uganda, while in Tanzania the decline in school absenteeism was offset by absence from class, something also seen in other countries (Bold et al., 2017; Chadhury, 2006).

Additionally, teachers present in class may not be teaching. Monitoring with minute-by-minute snapshots revealed lesson time lost varying between 18% (in Nigeria, the lowest absence rate) to 3% (in Uganda, with the highest absenteeism rate). Across SSA, about 10% of schools provide five hours of teaching daily, and an equally large share provides no teaching at all. Altogether, on average, students receive 2h 46 min of instruction per day - about half the scheduled average time. The highest country average was Nigeria, with just over 3 hours, and the lowest was Mozambique, with 1h 43 min. The average compulsory instructional time in OCDE countries is 4.5 hours.

Teaching and learning materials availability, use and effectiveness[1]

The most common teaching and learning material (TLM) is the textbook. Textbook-per-pupil-ratio (TPR) is a common metric of resource availability. Textbooks can be teachers' only support in delivering the syllabus. Availability has been considered one of the most effective interventions. Most material inputs were severely lacking in SSA for the last decades. More recently, some countries managed to source textbooks in adequate amounts or even above demand (Read, 2015). Others (i.e., Botswana, Kenya, Malawi and Namibia) could not match enrollment, despite increased provision. In Malawi, the percentage of students who did not have a textbook or who shared with at least two colleagues increased from 28.5% in 2000 to 63% in 2007 (UNESCO, 2014).

Out of 33 SSA countries with data indexed by the World Bank (Nordstrum, 2015), six managed to reach 1:1 TPR, and another five surpassed it. 11 countries had between 1:1 and 1:2 TPR, where students likely have some access to the material without individual provision. Alternatively, this could suggest high heterogeneity, with provision covering only some schools. The remaining 11 countries had 1:2 TPR or more. Cameroon reached 1:12, followed by Chad, with about 1:5.

The Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ), which administers international assessments in the region, shows the availability and trends in textbook access for 6th graders and differs greatly from the World Bank's data. Countries which should have surplus textbooks still hadn't reached 1:1 TPR. Swaziland and Lesotho show high figures, but many countries have a hard time providing textbooks for even half of their students; Tanzania specially lags far behind, with barely any pupil having their own textbook.

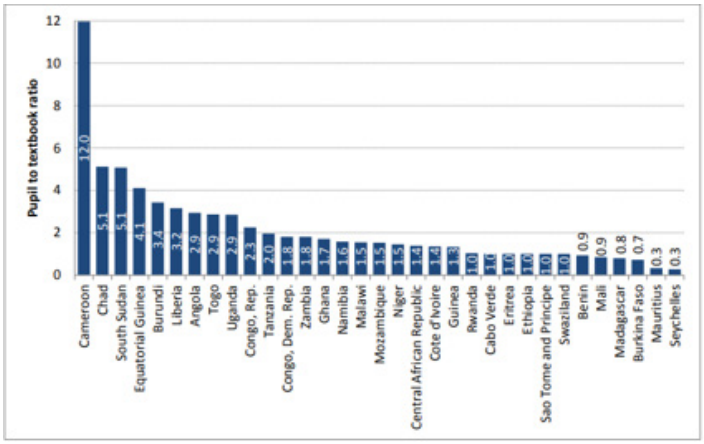

Figure 1: Pupil-textbook-ratio in SSA countries with data indexed by the World Bank Source: Nordstrum's (2015) rendering based on data from The World Bank's DataBank Education Statistics http://databank.worldbank.org/data/databases.aspx

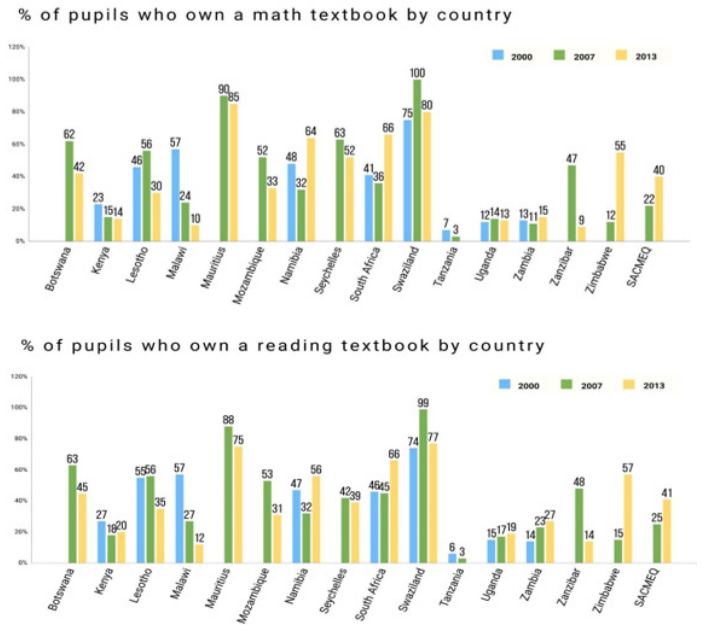

Figure 2: Of pupils who won reading and mathematics textbooks by SACMEQ country. Source: Author's own rendering based on data from the SACMEQ 2 and 3 (Hungi et al., 2011; Spaull, 2012) and 4 (Awich, 2021).

1 Much of the information in this section has been originally compiled and presented in Read's (2015) book "Where have all the textbooks gone?"

Data can be unreliable. Many schools have no records, and teachers who say they "don't remember" how many textbooks their school has likely have none. This fails to compose the average and is counted as missing data. A study of 13 schools in Namibia (Bontoux, 2008) finds core TPR usually stays between 1:1 and 1:4, though some schools are completely unattended, leading to averages of up to 1:62. Between 1997 and 2006, Rwanda received substantial funding for primary textbooks. Both government and development partners (DPs) assumed 1:2 TPR had been reached nationwide. Research involving two thirds of districts (Umubeyi & Bontoux, 2007) revealed that, despite heavy funding, grade 1 TPR averaged at 1:20 for French; 1:143 for Kinyarwanda and 1:180 for math.

Timing cripples effectiveness. Funding is often released late, leading to late printing, distribution, and increased costs. The Tanzanian Primary Expenditure Tracking Survey (Claussen & Assad, 2009) found that many schools received their first grant allocation several months into the year, with corresponding delays in textbook delivery. 89% of Tanzanian teachers reported not starting the year with the correct number of textbooks. 75% waited more than three months before receiving them (Brombacher et al., 2013). The majority of Kiswahili (81%), English (75%), and mathematics (75%) teachers reported having inadequate classroom materials for these subjects.

Availability does not imply usage or effectiveness. Benefits of textbooks seem to be much weaker than assumed when excluding less rigorous studies. A comparison of 40 experimental and quasi-experimental studies on the cost-effectiveness of various inputs (Evans & Ghosh, 2008) and a meta-analysis of 76 randomized controlled trials (RCT)'s on 110 inputs (McEwan, 2013) both found textbooks to be a low-cost, effective intervention, but noted research was not robust to checks from study moderators. A summary of results from 13 RCT's (Glewwe et al., 2011) found textbooks had no statistically significant effect on learning. Two other studies (Glewwe et al., 2007; Kuecken & Valfort, 2013) found that textbooks in their current form are only beneficial to high-achieving students. Even then, in one study (Kuecken & Valfort, 2013) high-achieving students only saw positive impacts for sharing textbooks, not for owning them. There is evidence that textbooks are more likely to lead to improvements in student learning if they are linked to changes in classroom pedagogy (Read, 2015). An international project providing free textbooks to all primary schools in Kenya found that it improved the quality of homework assignments, child-centered learning and classroom reading time. In a sample of 159 classes, 84% of teachers used textbooks (DFID, 2006). The following year, a randomized evaluation by the National Bureau of Economic Research (NBER) in the United States pointed out that scores only improved for students with high initial achievement. Low and average achieving students saw no overall impact, likely because the textbooks were in English, most students' third language, and many could not read them (Glewwe et al., 2007).

Poor textbook practice is widespread. In Uganda's Primary Curriculum Review (and likely elsewhere; Read & Hicks, 2004), reading, writing, listening, and speaking were not allocated enough classroom time, and teachers had no skills to do so. Oral work is fundamental for reading, though an "oral approach" often results in simple rote learning. In classrooms, teachers read each sentence of a text, and pupils repeat it several times, or write it down in their notebooks (Read, 2015); or teachers write from their textbooks on the blackboard as students copy, with no explanation. In a study with 204 Namibian children (O'Sullivan, 2003), 88% were unable to read a text from one year below their grade, though they could "read" the current reading book perfectly without looking at the text.

A review of classroom practice in South Sudan (Mikulska, 2014) likewise finds classroom time is spent with teachers copying from textbook to blackboard and asking students to memorize by copying from the blackboard into their notebooks, which are collected for marking. Teachers spend up to 15 hours a week in the staffroom marking notebooks. Very few spent their time teaching. This did not change, although the TPR went from 1:60 to 1:2. In a training workshop on effective TLM use in Namibia (Hiddleston & Hovelmann, 2013), trainers concluded many styles of textbook usage reported by education officers and teachers were inadequate. There was little evidence of creative use of TLMs. Most teachers didn't prepare lessons in advance and relied on the textbook to get them through the class. With no preparation, teachers' manuals were not very helpful and didn't see much use. A leading editor in textbooks for SSA stated she had never met a teacher who used any of the teacher's guides designed to accompany and support student textbooks (Read, 2015).

A significant part of the problem was teacher's lack of confidence on their own knowledge of subject content, skills and competencies specified by the syllabus. When textbooks were used, it was most likely to conceal teachers' insecurities. In South Sudan (Jones & Sayer, 2013), 54% of teachers had no training, and 70% were more familiar with Arabic than English. Teachers did not issue available textbooks to students because they feared being asked questions they could not answer about an unfamiliar language. This situation also occurs in other countries and is especially common in math, science and language textbooks. Alternatively, teachers may prefer to keep textbooks from students so that they will not know as much as them (Read, 2015).

Besides ineffective use, textbooks are often not used at all. In many SSA countries, continued lack of textbooks over many years conditioned teachers to operate without them, either because they grew accustomed to operating without textbooks, forgot or never learned to use them. A national survey of Tanzania (SIDA, 2000) found, although 40% of schools had class sets of textbooks, only 4% used them. In northern Cameroon (Buchan, 2013), schools have not had any textbooks for so long, no child has ever used one. In Uganda, with a 1:14 TPR, just 14% of public and 3% of private-school classes used the textbooks available (Wane & Martin, 2013). Results were in line with another Ugandan study from over a decade earlier (Kalibbala, 1999). Similar reports surfaced in South Sudan (Jones & Sayer, 2013), Zanzibar (Little, 1995; Vere, 1993), Sierra Leone (Sabarwal et al., 2012), the Democratic Republic of Congo, Ethiopia, Ghana, Guinea, Namibia, Rwanda, and other SSA nations

over the last two decades (Read, 2015).

If schools have textbooks and teachers want to use them properly, other obstacles exist. Most classrooms (even when development partners (DPs) are involved in designing and financing them) do not specify built-in lockable storage (Read, 2015). Book storage is often in the head teacher's office or an adjoined room. Collecting and returning books to a central store daily is tiresome to the point that many teachers eventually cease to use TLMs regularly (even more so if the headteacher is absent since he takes the keys). TLMs go unused for months for a simple lack of access. This was the case in three primary schools observed in Ghana (Read, 2010). In one, many books suffered serious water damage due to poor stocking. Insecure storage leads to theft; poorly managed and untidy storage leads to loss and damage; lack of weatherproofing and coverage exposes books to rain, dust, fungus, vermin and insects. If left unchecked, book stocks may be completely destroyed. In schools alone, 10% stock losses are not uncommon, and up to 50% annual stock loss has been reported (Read, 2015).

If used properly, textbook content may be lacking. Relatively little research has been directed to the quality of textbooks or the added value of using a good textbook instead of a bad one (Read, 2015). In developing countries, pupils usually spend more than a year in the first grade and then progress slowly, maybe because the level of instruction is too demanding (Lockheed & Verspoor, 1990). The language level itself is often too high. A content analysis (Cope et al., 1989) found math and language books to require work unrealistically above expectation for the grade, especially given the lack of pre-reading activities available. A comparative analysis (Benavot, 2010) points out that textbooks tend to be more specific than national curriculum guidelines, especially reading and literacy textbooks for primary school.

Many curricula are heavily inflated, reaching up to 12 subjects, each with its own textbook. Content takes little notice of other subjects, with much repetition. Many subjects have no trained teachers and content is extensive to the point that it could never be delivered without rushing. National curricula increasingly emphasize learner-centered and outcome-based approaches, development of competencies and higher order thinking skills; influenced by European and American school systems. Textbooks mostly fail to support teachers in these approaches. They concentrate on presenting facts; have no orientation for activities, no exercises and experiments specific to poor and rural schools; no balance for competency-based activities in different subjects and grade levels.They also have no content for multi-ability groups; no strategy for dealing with the wide variety of contact hours, teacher training, teacher quality and motivation between and within countries. In addition, there are no formative assessment exercises for teachers to determine if students are progressing on the required skills. Content that is not tested is often not taught.

Ministry of Education (MoE) documentation for publishers is closely adhered to. Since it does not consider variability in schools' conditions, publishers do not either. Curriculum developers seem unable to define required "skills and competencies", often because they are unsure of what these are, how they should be achieved, and have not been required to teach them. Methodologies to be developed are, likewise, mostly absent or unclear. Publishers are left to figure that out, on the risk of losing the bid if they get it wrong.

Inadequate curriculum design is frequently paired with the inability to inform teachers about its content and objectives. Teachers then generally revert to factual recall. Examinations do not follow curriculum development, and curriculum development has not taken them into account. A study from Zanzibar (Read & Ibale, 2007) remarks not only on the overloaded content requirements but also the absence of appropriate objectives, non-completion due to time constraints, lack of teacher preparation and inadequate provision. Only 19% of Uganda public school teachers showed mastery of the curriculum they teach (Wane & Martin, 2013) – a situation common elsewhere in SSA.

TLMs in SSA are not properly supporting teachers and students, though sometimes concentrating considerable funding and effort. The whole idea of what they are and the role they should fulfill is unrealistic for most schools, teachers and students. This unrealistic idea is then poorly executed. TLM effectiveness also depends on teachers' classroom practices, so training and manuals might be prioritised over textbooks.

Is education in Africa doomed?

The circumstances described in this paper, which are only a fraction of this incredibly complex scenario, may give off a pessimistic tone. Indeed, there are no magic solutions to the sizable challenges SSA education faces. It does not mean there is no solution, though this is not always clear in this intricate context.

Nonetheless, it would be inaccurate to state that education in SSA is doomed. There are African teachers who achieve good outcomes with their students, both in wealthier regions where stereotypical African conditions are less prevalent and in poverty settings. Even for those who may not achieve expedient educational outcomes, there are teachers, students, schools, parents and officials who go above and beyond to do their best and get results in this most extreme of educational environments. In the data presented here, a minority of schools and teachers do overcome issues such as lack of content knowledge, absence and classroom time. Qualitative data indicates cases of extreme resilience.

In Tanzania, parastatal publishers dominated the textbook market. The Government of Tanzania provided inadequate financing levels, leading to decreased sales, cashflow problems, shortages of working capital, shortages of raw materials and rapidly increasing debt. This led to a further drop in textbook provision and publishing standards. Both public and private schools struggled, and in many rural secondary schools, there were no textbooks at all. However, against all odds, a few select schools managed to reach 1:3, 1:2 or even the extraordinary 1:1 TPR, because sets of old textbooks had been lovingly maintained and repeatedly

rebound (Read, 2015).

Malawi is the seventh poorest country in the world and has consistently ranked amongst the poorest (International Monetary Fund, 2022). 15% of the population is under five years of age and the average age is 17 years old (National Statistical Office, 2019, p. 16). Class sizes often surpass a hundred, with kids ranging in age from 4 to 17. Few progressed past the primary 1, and only 31% stay until Standard 8 (the final year of primary school; Ministry of Education, Science and Technology, 2013). In a rural school in southeast Malawi (Werning et al., 2016), class sizes averaged at 70. There were traditional initiation rituals for the older children, where many girls would afterwards get married or pregnant, and where boys would often start working and stop obeying teachers. Thus, both boys and girls eventually dropped out and ceased their education. Most of their families also had received little to no education and were subsistence farmers. Still, a teacher reported they tried to stay daily at least half an hour after the school shift to help students, even from other classes, who were "slow learners'' or had learning difficulties. No one required this, nor was it mandated by the government. There were no specific prizes or punishments to the teacher, and it was, in fact, unpaid labor – something the teacher was very aware of and did not mind.

The headteacher had prepared mixed seating plans to improve the acceptance of children's diverse educational needs. Likewise, mother/father groups were incredibly active and counseled the students. They went after girls to get them into school, prevent them from dropping out or get them to come back if they left. Also, they got both positive role models to talk to and inspire students at risk and case stories of older women from their community to talk about how they gave up studying when they got pregnant and later regretted. For girls who were unwilling to listen, they would still keep track of them, and look for an opportune time to approach them again. They also talked to the parents of kids who dropped out. Although they appreciated the NGOs who gave humanitarian aid, they felt the focus on girls was leaving boys unattended. A father`s group was then made specifically to help boys. The groups of parents also cooked porridge for the children, tended to fish in the pond and cultivated the school garden, whose product they sold in the market, and thus garnered extra funds for the school. The children who benefitted were not necessarily theirs, as vulnerable children in the school included orphans, kids with learning disabilities, visual or hearing impairments, and other physical disabilities. Kids in the vulnerable group remarked on how the teachers taught well and questioned the students individually, to help them understand. The children also said they did like going to school most of the time. They liked reading, writing, playing with friends and reviewing classroom content, although this was not universal, and some students were also discriminated against.

What educational success has been possible, especially in rural or informal areas, relies, sometimes heavily, on voluntary work and informal structures of collaboration and support. The impact of community involvement and effectiveness of community monitoring has been noticed in the literature. Decentralization may be a key component for successful intervention, especially where centralized institutional means are less robust and capable, what has been conceptualized as "short route" accountability (World Bank, 2003). Although evidence is mostly qualitative and case studies, it does point to positive impacts of such approaches (Bruns et al., 2011). A report from the Chikhwawa district, Malawi (Mwanza & Ghambi, 2011), indicates a community scorecard process as an accountability mechanism was useful in stopping child-labor (rampant in some schools). It also committed specific actors to monitoring and finding evidence of poor salary administration in schools, consequently leading to changes in salary payment to teachers.

Some contexts may require easing intervention or consideration for more bottom-up approaches. Social responsibility interventions' effectiveness is highly contextual, but there is evidence of successful cases. It involves the matter at hand, the capacity of a particular community and the openness of influent government personnel, among other factors (McGee & Kelbert, 2014). It is unclear how much upscaling or institutionalization informal structures can bear, which requires caution. If the effectiveness of decentralized grassroots efforts is their decentralized grassroots nature, upscaling paradoxically destroys it.

Alternatively, informal networks of success might speak not necessarily to the strengths of communities, but to governments' inherent and present incapacity. Often, organizational issues and institutional constraints seem to be at least as important as intervention design. After successes with contract teacher interventions in India and Western Kenya, an RCT (Bold et al., 2012) investigated expansion to 14 districts in eight Kenyan provinces. A third of the sample served as control; a third had the intervention implemented by the international NGO that previously implemented it successfully; and a third had the same intervention implemented by the Kenyan MoE. Timing, salary levels, recruitment procedures and other experimental protocols were held constant. Geographical heterogeneity made no difference. Where the program was administered by the NGO, there was an increase of 0.19 standard deviation on combined math and english scores, consistent with previous research. Where the MoE administered it, there was no effect, probably reflecting the challenges of centrally administering a program which required local recruitment and monitoring.

Despite dire circumstances, there are cases of educational success in Africa, and their nature points to the persistent will of those most affected to make education work. Although harnessing and applying such efforts on a large scale is much harder than simply noting their existence, the desire for and dedication to schooling is and will likely continue to be a key component in guaranteeing proper education across SSA.

Closing remarks

This review covered some of the evidence on the conditions of teachers in SSA, providing a sense for the challenges low-income regions may face. Acting on developing an

educational system requires a thorough understanding of its complex practical functioning.Education for All (EFA) initial and continued inability to provide significant learning is partly due to the rushing and inflexibility it intrinsically carried. On the principle that universal education was ethically reasonable and politically satisfying, spurious amounts were spent without the expected return on investment. Part of the failure to provide adequate and sustainable solutions can be attributed to the failure in recognizing failed approaches, low institutional memory, and poor dissemination of what information is available on good, bad and (in)effective practices.Collecting and organizing evidence is highlighted in this review to emphasize the need for greater sensibility to the peculiarities of each context while maintaining an absolute, ruthless and unwavering realism for what can be accomplished, under which conditions and with which resources as it relates to practice, processes, inputs and outputs.

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Low-fee private schools and the teaching of mathematics in Sub-Saharan Africa

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Abstract

This review paper summarises direct experience with and studies of low-fee private (LFP) schools in sub-Saharan Africa (SSA). Parental fee payments mean a direct contractual link between family and school that is not present at government schools: it means that teachers must show up and teach most of the time, and look after the children in their charge for the duration of the school day. This schooling phenomenon has its roots in the 1990s, but despite being directly accountable, low-free private schools have not proven a solution to the challenge of low educational quality in SSA school systems. In this paper, I will describe the development of this shadow system, the scientific studies on the pros and cons of these schools as well as discuss the reasons why even the most structured LFP schools have not lived up to their supposed promise.

Introduction

Throughout the entire post-colonial period, sub-Saharan African education systems have been in a state of great difficulty resulting from the pressures of rapid expansion, part of 'the world educational crisis' as described by Philip Coombs of UNESCO as early as 1967 (Coombs, 1968). This was rebranded by UNESCO in 2014 as "the global learning crisis", but Coombs' description of the dearth of well-prepared teachers could have been written now, and his warning of "errors harden[ing] into habits able to resist even the stoutest of hammers later used against them" has an unfortunately canny ring to it (Coombs, 1968, p. 6).

Children often emerge from primary school in SSA illiterate and innumerate. At the risk of sweeping generalisation, government school systems fail to ensure that conditions are conducive for teachers to be reliably in class and teaching and that all of the necessary material supports are present. The reality is schools that are severely overcrowded with pupils who lack much in terms of practical and material support in their households, armed only with aspiration. Overwhelmed, under-educated and unsupported teachers find it hard in such circumstances to sustain dedication and commitment to their work. Various writers in the 1960s were already warning of teacher shortages and the perils of filling classrooms with 'volunteers' (Hansen, 1965; Indire & Hanson, 1971).

Enter the low-fee private school (LFP), which has mushroomed across a large number of national and sub-national contexts (Rose, 2002), firstly in poorer urban areas, and increasingly in larger villages. While debate rages regarding the desirability of this trend, individual school proprietors in ever-growing numbers go about their daily business of providing education after a fashion. It is now widely accepted that these schools exist, for better or for worse, and the debate moved on some years ago to whether these schools were providing reasonable quality (Härmä, 2021). Now questions swirl about their contribution to the achievement of Sustainable Development Goal 4 (UNESCO, 2021), something the proprietors themselves likely are not much concerned about. The central question regarding these schools is whether low-fee private school teachers (for whatever reason) teach more effectively than their government school counterparts. If they are found to do so, is this what explains the higher raw test scores that pupils at these schools achieve, and further, if this is the case, can this power be harnessed? Whatever the answers, the circumstances that gave rise to the LFP phenomenon are ignored or discounted at policymakers' peril.

This article does not go in depth into questions of pedagogy or teacher training for the teaching of mathematics – these are questions for other articles in this volume. This article will consider the current situation of teaching mathematics in LFP schools in SSA drawing in particular on studies from Kenya, Ghana and Nigeria, and also on my many personal experiences in observing lessons in such schools during research studies on their incidence, costs and accessibility (my work can be found at www.joannaharma.net and in Härmä, 2021). The next section will provide some background on low-fee private schooling in sub-Saharan Africa. Next, I explain how learning levels are generally low, before moving on to explain why this is the case even at private schools. The following section considers whether private schools are innovating as expected by some commentators. The final section draws out some of the key issues, some tentative suggestions, and concludes.

Background

There is ample evidence of the sorry situation in government school systems as regards learning (see UNESCO's annual monitoring report series starting in 2002 (to present)). Elite private schooling is not new, and schools serving middle-class families have existed for decades in most countries in the South. Mission schools have provided probably the oldest presence of non-state schooling in most countries, often from before there was state schooling in its current (colonial-style) form (Nishimura & Yamano, 2013), and in many countries post-independence, these schools have been partially absorbed into a state system of provision, with a variety of arrangements including the deployment of civil service teachers to mission-run schools. This form of state support has had the effect of making these schools closer to public than truly private (meaning, user-fee-funded) provision (Kingdon, 2007).

For the most part, it is where the money comes from for running the school that is the crucial factor here, and this article focuses on a newer development dating mostly from the 1990s, and which has gathered pace over the intervening years. This is the advent of the LFP school, entirely dependent on the fee income from parents for its survival (Tooley & Dixon, 2006; see Härmä (2021) for a full discussion of how 'low fees' are defined). The fee payment means a direct contractual link between parent and school that is not present at government schools: it means that teachers must show up and teach most of the time and look after the children in their charge for the duration of the school day. This schooling phenomenon has its roots in the 1990s when individuals within a community started to notice a lack of some kind (either no school at all close enough to home, or teachers not performing their duties sufficiently), and started to teach groups of neighbourhood children. From a small tutoring group, at the request of parents, primary schools have been born (Tooley, 2009).

As the trend has grown, it has become more common for an individual to start a new school with intention, from just a handful of children at least nominally divided into pre-primary classes and primary one or possibly even primary two. As they attract parents, schools grow and add a grade level year after year. Such schools are housed in a great variety of types of structures: apartment buildings, unfinished houses or converted houses, shipping containers, shops, churches, flimsy shacks or just under trees. Some have low walls made of some type of blocks, possibly of mud, with timber struts supporting a roof structure. Nearly all of the latter types have corrugated iron or tin sheet roofs and earth floors. Some schools are housed in a mix of structures because there have not been the necessary funds to build a substantial school building; some have to be split between different sites within the community because land is difficult

to come by in dense, urban environments (Härmä, 2021).

Some schools might have a few weak light bulbs, but often there is no source of power at all, or if there is wiring for lights, power cuts make this extremely unreliable. Many do not have any toilets at all or have basic pit latrines. There are usually desks and benches for children to sit on, but in some countries where I have observed schools, there are none. What teaching and learning materials there are is usually extremely limited, with parents not buying the textbooks, or buying them one at a time across the first half of the year, and teachers usually have only the textbook to work from, and a chalkboard. Teachers in these schools are often unqualified as per government standards, but this varies greatly from one country to another and depends on the flow of graduates emerging from teacher training colleges (Härmä, 2021).

Such schools are often illegal and unregistered with education authorities because governments tend to have very demanding regulations regarding private schools, often far surpassing what is offered at public schools (Baum et al., 2018). In addition, dealing with government authorities tends to involve the payment of bribes in order to become registered or in order to avoid being closed down due to lack of registered status (Baum et al., 2018). No country that I have conducted research in where there is a thriving LFP market has managed to develop an effective regulatory system for these schools (Härmä, 2021).

The key message is that these schools are characterised by informality in both staffing and infrastructure. What is taught is an exception to this overall informality: LFP schools invariably teach the national curriculum because this is what parents demand. Parents are voting with their feet in what seems to be ever-increasing numbers[1], but a key question (of many questions, including whether these schools exacerbate inequality and further undermine government systems) is whether these schools are doing any better than government schools. Is the investment by parents with scarce financial resources worth it (Srivastava & Walford, 2016)? The next section addresses the crucial quality issue, focusing on the teaching of mathematics.

What does the data tell us about learning at LFP schools?

Parents perceive that private schools do better than government schools in a number of areas, however, there is no data, nothing concrete by which parents choose (Dixon et al., 2017). Their choices tell a story of dismay with government-provided schooling and desperation for something better. I have written extensively about parents' perceptions of school quality elsewhere (Härmä, 2013, 2016, 2021), so this article will focus on a handful of studies that have looked into learning levels in detail.

1 Space constraints here mean that the incidence of attendance at private schools cannot be addressed here. For particular examples see my open access reports on Lagos, Nigeria (Härmä, 2011; Lagos State Ministry of Education, 2011), and Kampala (Härmä et al., 2017). See also the UNESCO (2021) which focuses on non-state actors in global education.

Overall learning levels are low

Firstly, there is a relatively long list of studies that have used test scores, taking into account ('controlling for') aspects of children's family background (their socioeconomic status) via econometric methods using a range of proxy and direct indicators of status and wealth. It is probably a majority that finds some degree of 'private school effect', meaning that even considering that private school pupils tend to come from generally more privileged households, there is still an advantage to be gained by attending private school. There are studies from Kenya (Bold et al., 2013; Wamalwa & Burns, 2018; Baum & Riley, 2019; Alcott & Rose, 2016 – the last study found this for Uganda as well). Tooley and Dixon find such an advantage in Ghana, Nigeria and India (Tooley & Dixon, 2006; Tooley et al., 2010). Many researchers find similarly for India (Alcott & Rose, 2015; Goyal & Pandey, 2009; Kingdon, 2007; Muralidharan & Kremer, 2008).

These studies finding 'private school effects' of varying magnitudes must be understood in their contexts of very low learning levels overall, so the actual 'value-add' of private schooling at the lower end often means a child's learning is somewhat less terrible than it would have been had the same child attended a government school. To illustrate the point: Ghana's National Educational Assessment of 2018 defines minimum "competency" as achieving at least 35 percent correct answers, and on the test of mathematics for primary 4 pupils, nearly half of the sampled children (48 percent) were unable to reach this very low bar. One-third scored 35-54 percent, while less than one-fifth were able to achieve at least 55 percent correct (Government of Ghana, 2018, p. 8). Considering public and private school pupils separately, the average scores were 37 percent and 54 percent correct, respectively (Government of Ghana, 2018, p. 17). Math scores were considerably lower than English scores, despite English being a non-mother tongue for most children. Similarly, in two Lagos studies comparing school types, scores for private school students (mostly attending LFP schools) were significantly higher than for government schools (EDOREN, 2018), and significantly higher in literacy than in math. In private schools in four areas of Lagos, just over half of primary 3 pupils had mastered the literacy curriculum, while this drops to only 6 percent in numeracy (EDOREN, 2015).

These snatches of data illustrate the macro 'take-away': that learning levels are low across the board except at more expensive schools (Ngware, 2013; EDOREN, 2015). Yet not all private schools targeting the relatively poor are made equal. Returning to the 2018 Lagos study cited above, it was actually aimed at evaluating the quality of Bridge International Academies' (Bridge) schools in relation to both government schools and the usual locally-owned LFP schools. Bridge is a multinational chain of relatively low-fee private schools targeting many of the same low-income areas as LFP schools, but at a somewhat higher price point than many. Bridge came up with a model for complete standardisation across a large number of school locations, 'teacher-proofing' the schools by providing them with scripts to be read word-for-word from an e-reader. Teachers in these schools are to deliver only what is in their scripts which are downloaded every week, and which are purported

to include answers to all types of student questions on the subject material. This means that teachers do not need to be trained in pedagogy or lesson planning because this is all decided for them at the company's 'back end' in the United States.

The company has spent enormous sums of money on research and development of the model (see Riep, 2019) that is touted as being so thoroughly standardised that teachers are rendered essentially interchangeable. The company provides a few weeks' crash course in using the e-readers with their scripts, in classroom management, and in marketing the school within the community. They train more teachers than they have roles for so that when a teacher leaves (high turnover being endemic to LFP schooling), they can quickly deploy a replacement. Each Bridge school teacher in a particular grade level in a given country should be delivering the same scripted lesson in the same way at the exact same moment of the school day, across all school locations.

Having given a sizeable grant to the company to aid its start of operations in Nigeria in 2015, the UK government funded an evaluation study of how Bridge schools were performing in terms of children's test scores in literacy and numeracy (EDOREN, 2018). The research team set the assessment based on the primary school curriculum and found that while Bridge schools had a statistically significant advantage over LFP schools and government schools in literacy, in numeracy, while there was, of course, an advantage over government schools, Bridge schools were found to have no advantage over individually-owned LFP schools *despite a truly enormous gulf between the school types in terms of the investment and research that has gone into the Bridge model*. This evaluation's findings indicate that it is the LFP model itself, rather than any particular way of running such a school, that proves a barrier to providing education of objectively good quality.

Why are things so bad even at private schools?

The challenge of poverty

This section turns to a consideration of what challenges confront private schools in efforts to teach mathematics – many of which are shared with government schools and with different subjects. First and foremost for all schools serving disadvantaged groups, especially in poor countries, is the challenge of teaching children growing up in poverty (Ogando Portela & Atherton, 2020; see Härmä, 2021, especially chapter 5, for a discussion of the roles of poverty and family background in children's learning, using global evidence). Studies find a crucial role played by poverty in learning, with schools struggling to make up for household deficits (Alcott & Rose, 2016). Whether living in an urban informal settlement or in a rural village, there is often little space within the home that is amenable to studying hard and doing homework. Distractions abound, and lighting might be hard to come by for evening homework. As soon as the child is home from school, there are chores to do, siblings to care for, and games to be played with neighbouring children. Added to this is the usual lack of a basic literate environment within the household. It may be the dearest wish of the parents that their child gets a good education, but they might not be able to help at all with homework, and may not realise how much support for the child's learning is needed. Children also lack access to textbooks and even writing materials (Akaguri, 2011; Fredriksen et al., 2015; Milligan et al., 2017; Härmä & Moscoviz, 2019). LFP school parents are responsible for buying the textbooks their children need, and yet many do not, because they stretch their finances terribly in order to afford the school fees of the most expensive-possible school within their reach, leaving them little to no funds to pay for the necessary materials (Härmä & Siddhu, 2017; Härmä & Moscoviz, 2019). These challenges are not to be underestimated, and they are impossible for any school to fully compensate for.

The lack of a dedicated & stable teaching workforce

Yet schools can make some difference, and teachers are the most important single aspect of school education. The idea of what a good teacher needs usually includes a good knowledge of the material they are teaching, gained from a good education; effective pre-service teacher preparation; a high degree of motivation, and a view of teaching as a vocation; and the teacher should be working in conditions that are supportive of their work in terms of both physical conditions and support from colleagues and the wider school community.

I argue that many of these conditions for teachers to excel are missing for possibly the majority of teachers of disadvantaged children in SSA. In LFP schools, there are considerable challenges, and there is a key inherent flaw of the model: turnover of the workforce. Low-fee schools mean there is little revenue from which to pay teachers, so salaries are very low, impacting morale and leading to high teacher turnover, something reported in every context in which I have studied this schooling type. Teachers are willing to leave one school for another where there is an offer of even slightly higher pay, leading to low levels of commitment to and investment in their staff on the part of school proprietors. With extra training under their belts seen as a selling point, there is no incentive for proprietors to invest in training, meaning no real, meaningful upward pressure on quality. Each new hire is seen as good enough for now, and until they move on (Härmä, 2021).

Today's young teachers have received a sub-par education themselves

Many teachers in SSA have insufficient subject content knowledge (Akaguri, 2011), which proves an insurmountable barrier to truly high-quality teaching and learning. In addition, teachers of lower grades and pre-primary classes commonly have lower status and pay, and less well-qualified individuals are deployed to this level. This is arguably a dangerous combination, especially for mathematics, as early learning in this area from the youngest ages is what all future learning is built on. In some places, virtually the entire teaching workforce is unfit, most likely due to the poor education that they themselves received. In Nigeria,

in 2008, all government primary school teachers in Kwara State, where I lived, were tested in four subjects at the primary 4 grade level of difficulty. Seventy-five out of 19,125 teachers passed (requiring an average score of 80 percent or higher). Many (259) failed to score any mark at all (ESSPIN, 2008, p. 2), but this should not be regarded as specific to one of the poorer and more remote Nigerian states. A similar assessment was carried out in the richest part of the country, Lagos, with results even worse than Kwara's (as the Governor refused to publish the findings, I was only able to learn about the Lagos assessment from my Education Sector Support Programme in Nigeria colleagues, who conducted the assessment).

In Nigeria, as in Kenya (Ngware, 2013) and so many other contexts where civil service teachers stay in their posts for decades due the job security and lack of accountability, government teachers are considerably older than those teaching in LFP schools. LFP teachers tend to start work at their first LFP school fresh from secondary school or some tertiary education (including teacher training in some countries), or during a break from their own studies. It is likely that many of yesterday's LFP teachers could have been educated by older government teachers like the ones assessed in Kwara State – and today's young LFP teachers might have been taught by yesterday's LFP teachers (or government teachers). It can therefore be no surprise if LFP schools fail to foster high levels of learning despite being more accountable. Logic suggests that there must be a ceiling to what a person can achieve (serving in the role of a teacher) who does not have a grasp of the subject matter. One retired civil servant from Uganda described the situation where unqualified individuals cheat their way into teacher training colleges: "Such fools later become 'teachers' and end up fostering the next generation of fools in the classes that they teach. It is not a surprise that we have many children failing their primary school exams" (Kisira, 2008, p. 166).

Returning to the extremely detailed study by Ngware, we learn that teachers across government and private schools in the six urban areas in the sample have worryingly low levels of subject content knowledge – the basic building block for becoming a good teacher. To begin with, 95 percent and 70 percent of government and formal private school teachers (respectively) were qualified, while only 41 percent of LFP teachers were (Ngware, 2013, p. 59). Government school teachers scored 52.2 percent on the subject content test; formal private school teachers scored 51.3 percent, while LFP teachers achieved 54.7 percent. The teachers were even weaker on pedagogical knowledge, with scores of 44 percent (LFP), 45 percent (government), and 47 percent (formal private) (Ngware, 2013, p. 67). It is noteworthy that there is so little variation even in this area when the majority of LFP teachers have not been through pre-service teacher training. It is significant too for the argument of this article that teachers in no sub-sector came out stronger than the others – their characteristics varied, but not in line with their scores on the tests administered to them.

This article purposefully avoids making assumptions regarding teacher qualifications. There is a rich literature on the deficiencies of initial teacher education programmes in SSA (Abadzi, 2006). Akyeampong et al. (2011) describe teacher training in six African countries, and even where this training appeared more organised, the report pointed to issues with the teaching of core concepts to build conceptual understanding on which to build, instead of memorisation of steps to follow to solve problems.

Are private schools innovating?

'Innovation' is a key buzzword often attached to private sector initiatives, especially in education. Public schooling globally is often characterised as stagnant, while private sector actors are supposedly incentivised by market forces to innovate and find new and better ways of doing things. Innovation is often sought even in the LFP sector where it operates, with the expectation that private actors will come up with more effective ways of fostering learning. However, I have not witnessed innovation in the hundreds of LFP schools that I have visited, where the methods are traditional chalk-talk methods, with question-answer sessions between teacher and pupils that usually do not include probing for a deep understanding of the subject matter. Returning once again to Ngware (2013), the researchers provide great detail on the key types of classroom activities that take place in the study schools, with no particular variation in style between school types.

There are considerable claims to innovation from larger school chains such as Bridge and SPARK Schools in South Africa. However, this 'innovation' does not reach the level of pedagogy: SPARK has made claims regarding innovation in a collaboration with Google for Education, but the detail revealed that this was only to do with the way teachers handle student assignments (itslearning, 2018). Bridge has innovated in how to manage in a context of poorly-educated teachers, with their tech-enabled management systems and the instant distribution of scripts to teachers to read from (Riep, 2019).

During my own time in LFP classrooms in SSA, I saw that Bridge schools 'innovated' through some puzzling classroom management techniques borrowed from the Charter School movement in the United States, but things were quite standard when it came to the delivery of the subject content. I observed mathematics being taught similarly to other schools as witnessed from the beginning of my own experience in school. In the common LFP school, I have witnessed lessons in all subjects that have been dull, slow-moving and devoid of energy, often involving copying from the board due to pupils' lack of textbooks (much class time is wasted in this way in SSA; see Abadzi, 2009; Akaguri, 2011). On the other hand, on my final day in the field on my last research project in rural Ghana I sat at the back of a small, cramped makeshift classroom with perhaps 15 pupils in it, with a very young (perhaps 22 years old) teacher conducting an inspired lesson on triple digit subtraction with borrowing. I could not say that there was innovation on display during this lesson, but the teacher was a natural, engaging with his students and patiently coaching as students worked through examples on the board, constantly reinforcing the concept of place value and probing for comprehension. I argue that in light of the current level of teacher education and the

poor state of initial teacher education for the teaching of mathematics at the early primary level (Akyeampong et al., 2011), innovation is a distant dream, and private sector schools do not offer any clearly differentiated product; they do not offer higher quality pedagogical approaches, based on observation of teaching methods rather than just test scores, and this is well explained in the in-depth study carried out by Ngware (2013) in Kenya. One caveat to this conclusion which still might not prove the innovation point, but proves a point of differentiation: research on this schooling model in fragile and conflict-affected states has found that there is less to fear in terms of indoctrination and hardening of perceived differences between communities as compared to state managed systems (Tooley et al, 2020). If this is the case, any reduction in conflict risk can be seen as an enabling condition for learning to take place.

Discussion and conclusions

The magnitude of the overall challenge in SSA is enormous. It cannot be a surprise that teachers struggle to teach mathematics effectively, when they do not have a repertoire of ways in which to explain and re-explain differently the mathematical concepts that they must teach. Indeed, teachers are documented as being unable to ascertain through appropriate questioning techniques whether their students understand what they are teaching – and where teachers do not know the understanding level of their students, how can they address students' issues? On the other hand, what good can such knowledge and techniques be when confronting a class of 80, 100, or even 150 students, as I have witnessed in some Nigerian public schools? In such a setting, the teacher only launches forth explanation at the front of the class and can only hope some students might grasp some of it. Another important factor enters in, especially in more rural settings – when higher primary grades' (and above) math content is taught and exams are set in a colonial language that is not the mother tongue of the student, it becomes complicated to ascertain where problems are truly problems of math learning or language fluency. This adds a whole new level of complication on top of the low-skill and high turnover of LFP teachers.

This article explored the role of low-fee private schools in the teaching of mathematics in SSA, but one of the key issues, the subject knowledge and pedagogical skill levels of the teachers involved appears to be a common issue confronting all types of schools. As the Ugandan civil servant cited above bluntly pointed out, such unskilled teachers will beget unskilled school leavers, some of whom will inevitably become the unskilled teachers for the forming of the next unskilled generation. The example of Bridge International Academies shows that there is only so far a model can develop when teachers are young, poorly paid, ill-educated, and untrained or effectively untrained as a teacher. This challenge of poor education is happening at full scale now, which means that there are no particular places where well-prepared teachers can be found who might help rectify this situation. No intervention or fix or crutch – such as the scripts of Bridge – can quickly address issues of such depth, breadth and profundity. The aim must be to build improvement in education systems slowly and surely, rather than trying to sprint to some imagined 'good quality finish line'. Rather than testing children, national systems may do well to keep track of the knowledge levels of their teachers by testing them instead, but only if the test score data can feed back into teacher training systems that then offer remedial instruction to budding teachers whose own education has been sub-standard (which is probably most of them). Realistic suggestions must be conservative and based arguably on an expanded mathematics subject content knowledge base for teachers. Then, developing pedagogical subject content knowledge must follow – yet the question remains as to where the teacher trainers of the requisite quality are to be found.

With regard to the specifics of low-fee private schooling, the key challenge is teacher turnover which disincentivises proprietors' investment in training. Those coming from a rights-based perspective in particular question why teacher salaries are so low in these schools (largely prompting this turnover). It is, for the most part, not out of an intention to exploit teachers. Something that must be understood about these schools is that they are entirely a product of their environments – and this means they are part of the informal economic sector of the informal settlements or villages where they exist. The clients these schools serve are usually employed similarly in the informal sector and often earn precariously and unpredictably. The fees that such parents are able to pay are necessarily low, and so a member of such a community who plans to start a school knows that it will only take root if the fee level is within reach for local families. It is for this reason that teacher salaries are so low, and teachers chop and change in search of even a vanishingly small increase in wages. Another aspect noted about these schools is that teachers are not protected by formal work contracts with clear terms and conditions – yet this cuts both ways, and proprietors find themselves down one member of staff at any moment during the school year and are forced to scramble to find a replacement quickly. They are loath to have to find such replacements, so they are not as quick to discipline and sack teachers as is often supposed. Coupled with this, salaries being what they are, teachers care less about losing their jobs than they otherwise might, which explains why teacher attendance at these schools is still far from perfect.

None of this spells success in mathematics learning, although the LFP model clearly has some benefits. Firstly, class sizes tend to be smaller than in government schools and are sometimes very small. The pupils are almost always significantly better-off than their government school peers, and while they may come from the exact same communities, the better-off in the neighbourhood will self-select into the private sector. In order to keep their jobs, LFP teachers must show up most of the time and put some effort in, even if they are not as motivated as one might like. Under such conditions, to the limited extent that teachers have the knowledge and some ability to convey subject content, it is much easier to do this in small private schools than in overcrowded, chaotic government schools. LFP teachers, therefore, experience a clear head start in relation to government school teachers, while at the same time, it appears that there is very distinctly a ceiling to what can be achieved where teachers have only a partial or shadowy grasp on the subject matter and no real

knowledge of pedagogical approaches. The Bridge model has illustrated that no amount of scripting and scaffolding is enough, and conditions in schools must be slowly improved to support newly trained teachers who should receive remedial subject and pedagogical methods instruction.

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Transferring and sustaining technological innovations after professional development: Insights from school leaders and teachers in Sub-Saharan Africa

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Abstract

Desiring technology-related change promotes reform-oriented technology integration to create a lasting impact on education. Nonetheless, most technology projects in Sub-Saharan Africa least achieved this target. Research points to quality professional development (PD) as a significant influence in achieving this. This follow-up study is on a cohort of 6,351 school leaders and teachers from six Sub-Saharan African countries who participated in a digital instructional PD targeted at building their capacity to embed ICT into school organisation and curriculum practices. The study sought to evaluate the impact of the PD programme in relation to the quality and the extent of the participants' transfer of the programme's ideas from capacity building to school organisation and classroom practices. A semi-structured survey instrument and diaries, kept to maintain records of activities and events during the period of implementation, were data channels. Findings revealed that stakeholder groups expressed general satisfaction with content and processes of the training programme; however, essential conditions to support transfer of the training's ideas to school level seemed inadequate during the period of implementation. Implications of the study for effective technology-related PD that have sustainable impact on educational practices particularly in Sub-Saharan regions and similar contexts are discussed in this article.

Introduction

Much advancement has been seen in this field of ICT in education in a relatively short time across the globe and resulted in the expansion of ICT infrastructure. These improvements in technology are penetrating most African countries (even before the outbreak of COVID 19) and are bringing about conditions that are gradually turning into homes of emerging ICT hubs. These developments seem to compliment the majority of ICT initiatives in Sub-Saharan Africa in the immediate past that have often focused on creating ICT presence in schools. Such ICT initiatives form the basis of the bulk of ICT development and practices in most Sub-Saharan countries even though educators' and students' access to ICT is still limited. While these initiatives do not seem to create a broad or lasting impact on education, their inheritance remain important; they allow for setting up new computer laboratories or hubs in schools and thus, improving access as well as goodwill from donor partners. The obvious and most critical issue that needs to be addressed is the question of sustainability – Niederhauser et al. (2018) reports that the essence and utmost importance of ICT initiatives or research projects must be to foster effective adoption that will support the long-term goals of the education policy.

These arguments also point to the importance of effective professional development (PD) programme in implementing ICT initiatives. Fortunately, in recent times, Sub-Saharan governments at different levels are focusing on strategies that do not only seek to increase access, but also build capacity for educators and students to improve the quality of education through ICT (United Nations Economic for Africa (UNECA), 2005). While the process has previously been painfully slow (Ottevanger et al., 2007), the situation has been improving in the last few years. A case in point is the Africa Digital Schools ICT-project that was launched recently under the joint sponsorship of the British Council and Microsoft and in coordination with the Ministries of Education of six Sub-Saharan African partner countries: Kenya, Tanzania, Uganda, Ethiopia, Ghana and Nigeria. The ultimate goal of the project was to influence policy for ICT integration to build ICT competencies in school leaders and teachers in order to enhance and transform school practices.

Key to the envisioned project roll-out was a network of 80 digital hubs (also referred to as digi-hubs) installed and made to operate in the six Sub-Saharan African countries. Each hub was equipped with twenty terminals which acted as centres of excellence that supported other schools. Cascading from the digital hubs, digi-hub ambassadors (known as digital ambassadors) and master trainers were supporting schools and teachers in the project countries with ICT professional development and ongoing support during the 18 months long project implementation period. The PD training programme was meant to develop school leaders and teachers' capacity to integrate ICT to enhance their professional practices across the beneficiary schools of the project. Several months after this intervention, what remains to be done is a follow-up to see if the training programme has yielded the desired results in the way trainees who took part in the training implement the knowledge, skills and attitudes gained in the training context in their practices. Fishman and Krajcik (2003) reported that in the space between originating context and broader applications or continuity, most innovations either disappear or become unrecognisable and as Fullan (2015) reported, a great majority of policies and innovations did not get implemented even when implementation was desired. This study is an independent one, carried out to explore how the project's PD programme was implemented in relation to the school leaders and teachers' development, school organisation, resource support, usage and changes.

Literature review

Transfer of learning

A number of studies have shown that though most research projects yielded valuable knowledge about the nature of cognition, teaching and learning, they failed to have a broad or lasting impact on education. These studies (e.g. Saks, 2002; Yamnill & McLean, 2001) point out that learning from a formal training programme is often not or in a limited way applied on the job. Questions raised normally centre around the degree to which trainees effectively transfer the knowledge, skills and attitudes gained in the training programme to a real world of work. Over the years, there have been studies and explorations of factors that thwart transfer, diffusion and implementation efforts. Prominent among those who have journeyed into this puzzling morass are Baldwin and Ford (1988). Baldwin and Ford (1988) identified a taxonomy of major conceptual factors influencing transfer. They divided these factors into three groups of characteristics which directly or indirectly influence trainees' learning and the transfer of training: trainee characteristics, training characteristics and work environment characteristics. Baldwin and Ford referred to work environment characteristics as external factors which directly and indirectly affect trainees' learning and transfer of training; trainee characteristics as internal factors (e.g. ability, personality, and motivation) and training characteristics as training design factors (e.g. principles of learning, sequencing, and training content). Bebell and O'Dwyer (2010) reported of other key factors to include the importance of leadership and support. The importance of administrative leadership in implementing and sustaining reform initiatives (see Niederhauser et al., 2018; Fullan, 2015) have also been reported in the literature – Fullan reiterated that effective school leaders are key to effective implementation of large-scale, sustainable education reform efforts.

Professional development for ICT initiatives

According to Webb and Cox (2004), one of the reasons for the unenthusiastic response to ICT-based innovation amongst schools is that technological knowledge and skills is either absent or lacking in the processes that underpin school organisation and teachers' planning. Training is therefore considered an important influence on how technology can be embraced in the classroom (Baylor & Ritchie, 2002). If school leaders and teachers are not trained or prepared sufficiently for their new roles with technology, then it could be that they merely will try to transfer classroom

practices to the new environment (Redmond, 2011; Kelz, 2011). Additionally, Meloncon (2007) indicates that teachers need to redefine themselves when they are changing their teaching place, e.g., the change to a technology-based learning environment. This stresses the importance and the need for PD on learning how to teach with technology and transform school practices. In this respect, recent research emphasises the need for more studies on effective PD that implement instructional technology in ways that encourage integration (for examples, see Goktas et al., 2008; Kay, 2006; Philipsen et al., 2016) into school organisational and curriculum practices even after the training.

The professional development arrangement

Prior to the conduct of this study, a PD programme was organised to target Science, Technology, English and Mathematics (STEM) high school teachers and their school leaders from six countries that participated in the study. Preceding the PD programme, a first stage capacity building training of selected master trainers from the participating countries was organised. The "Master Facilitator Training Programme" was aimed at building the capacity of the trainers to enable them to train selected school leaders and teachers as well as to get them to familiarise with the content of a training manual that had been designed for the PD programme. In the following stage, the master trainers were to offer training programmes to the school leaders and teachers (using the training manuals) to be extended to the school communities of the various participating countries.

Table 1: Overview of the training programme manual.

Session	Content
1	Managing and Leading Change
2	Leading Effective Teaching and Learning
3	Creating and Communicating a Vision
4	Goal-Setting for Success
5	ICT Skill Development
6	The Benefits of the International Dimension and Technology
7	Building Teams
8	The Power of Coaching
9	Action Plan
10	Leading Effective Teaching and Learning
11	ICT Skills for Teachers – Word
12	ICT Skills for Teachers – PowerPoint
13	ICT Skills for Teachers – Excel
14	Using Microsoft AutoCollage
15	Using Microsoft Photo Story

The training manual was intended to be used to support teachers during the training sessions and, subsequently, to be used by the participants in their own local school settings. The training manual consisted of 15 sessions in all. The material also provided a facilitator manual with orientation for guiding participants through each session of the course. Strategies in the course delivery were focused on participatory methodologies with guidance orientation on an 80:20 rule in which 80% of talking and activities doing came from the participants and 20% of guidance and instruction from the facilitators. Table 1 gives an overview of the content of the training manual.

Conceptual framework

The Guskey model was adopted in the current study to examine the evidence of effectiveness of the PD programmes impact at each level of the model's influence from training to practice. Thomas Guskey is an educationist who has been writing for some time about the importance of seeking evidence of the effectiveness of PD models and programmes (see Guskey, 1985, 1986, 1990, 1991, 1998; Guskey & Sparks, 1996). According to Guskey (2002, 2017), effective PD evaluations require the collection and analysis of five critical levels of information: Level 1: Participants' Reactions; Level 2: Participants' Learning; Level 3: Organisation Support and Change; Level 4: Participants' Use of New Knowledge and Skills and Level 5: Student Learning Outcomes. With each succeeding level, the process of gathering evaluation information gets a bit more complex. The model also explains that success at one level is usually necessary for success at higher levels because each level builds on those that come before.

The present study sought to apply Guskey's model to explore the efficiency, effectiveness and relevance of the PD training programme. The evaluation focused on four levels of the model impact, namely:

- Level 1: School Leader and Teacher Reaction focused on general impressions about the digital training programme and its components (e.g., quality and effectiveness) in transforming school practices;
- Level 2: School Leader and Teacher Learning, focused on the quality of learning during the training (e.g. the change in competencies, self-belief of digi-hub use in teaching and school organisation);
- Level 3: Organisation Support and Change focused on schools' conditions and practices that underpin or support school leaders and teachers' implementation efforts and recognition of the digi-hub in teaching, learning and school organisation (e.g., things planned to do or changes after training, plans in place for ICT use);
- Level 4: School Leader and Teacher Use of New Knowledge and Skills focused on the use of the training programmes' ideas in practice. At this level, the emphasis is on whether school leaders and teachers were applying the knowledge and skills they had acquired during the training in their professional and teaching practices.

The relationship between PD and improvements in student learning in this setting was far too complex and difficult to measure, since the entire project spanned over a period of 18 months. In such a case, collecting good evidence about whether a PD programme has contributed to specific gains in student learning was a difficult task. Hence, level 5 of Guskey's model was not considered in this study.

Research questions and research design

This study aimed at evaluating the impact of an instructional digital PD programme on high STEM high school teachers and their leaders from the six Sub-Saharan African countries who participated in the study and was guided by two research questions.

(1) How did the participating school leaders and teachers perceive the contribution of the PD programme to developing their experiences of the instructional digital innovation to enhance their professional practices?

(2) To what extent did the PD programme promote transfer of learning among the school leaders and teachers?

In the study, 'transfer of learning' referred to whether new knowledge, skills and attitudes acquired by participating school leaders and teachers during the training programme were being applied or used in their professional and teaching practices. The study employed an embedded mixed method research design (Creswell et al., 2003), including the collection of quantitative and qualitative data.

Methods

Participants

6,351 participants consisting of 4,945 teachers and 1,406 school leaders from all the six countries responded to the survey. This constitutes a 90.1% response rate from the total of 7,050 participants who took part in the PD and were expected to respond to the survey sent to them. Table 2 gives the breakdown of the participants by country and gender. The highest number of 1,909, constituting 29.6 % of the total respondents was from Uganda.

Table 2: Distribution of respondents by country and gender.

Country	School Leaders	Teachers	Total	M (%)	F (%)
Ghana	233	688	921	87.9	12.1
Ethiopia	508	556	1064	86.9	13.1
Nigeria	92	545	637	53.0	47.0
Tanzania	138	1051	1189	41.7	58.3
Uganda	200	1709	1909	41.8	58.2
Kenya	235	396	631	34.3	65.7
Total	1406	4945	6451	61.1	38.9

The lowest (631) response was from Kenya and this constituted about 9.8% of the total respondents. Table 2 gives an overview of the distribution of the respondents by countries. The summary profile of the respondents' gender showed a higher male to female ratio of about 61: 39. With respect to age distribution, the majority (47.5%) of the total respondents fell within the age range of 25-34 years. About 47.3% were either within the age group of 35-44 or above 45 years. Only a small percentage fell within the lower age ranges of 16-20 (0.3%) and 21-24 (4.9%).

Data collection and analysis

Teacher questionnaire

This study adopted an online survey evaluation tool which was used previously for the data collection during the PD programme for the participants. The survey was made of a semi-structured questionnaire developed and used to collect data at the first four levels of Guskey's model. Items on the survey included perceptions of participants of the training programme and what they learned from the training. For these items, a five-point Likert scale (1 = strongly disagree, 5 = strongly agree) was used. The scores were interpreted as follows: 1 is the lowest possible score, which represents a very strong negative perception, while 5 is the highest possible score which represents a very strong positive perception. The questionnaire also contained an item in which respondents were required to make recommendations to other colleagues based on their own experiences with the training programme. They were to rate on a scale ranging from 0-10; where 0 = very unlikely to recommend and 10 = very likely to recommend. The survey also included an open-ended item which required respondents to explain three things they would like to do or change as a result of the training. The focus was to explore the potential influence of the digi-hub post-training on practices and to verify the potential enabling conditions for supporting ICT implementation efforts in school organisation. In analysing the data, closed-ended items were analysed using descriptive analysis, t-test and analysis of variance test. For open-ended items, quantitative content analysis was used. This analysis focused on generating and coding themes or categories (Miles & Huberman, 1994) based on the school leaders' and teachers' responses followed by a systematic quantitative analysis of the occurrence of particular categories/themes.

Digital Ambassador diaries

Digital Ambassador diaries were used to maintain records of activities and events at the various hubs during the training programmes. Data collected referred mainly to the training content and processes of the training challenges encountered during the training programme. The information recorded and analysed qualitatively used data reduction techniques (Miles & Huberman, 1994).

Results

Using Guskey's framework for evaluating the PD programme, data were analysed at four levels of the training programme and its implementation. The following summary provides an overview of findings from the analyses.

School leader and teacher stakeholders reaction on the training

The first level of the evaluation focused on the school leaders' and teachers' views on the training programme. The purpose was to explore the level of quality of the

training programme and the extent to which the training met their expectations. The results showed overall highly positive perceptions for both teachers (M=4.36, SD= 0.57) (i.e. approximately 'agree') and school leaders (M=4.42, SD= 0.36) (i.e. approximately 'agree') of all the participating countries.

Table 3: Descriptive statistics of school leaders and teachers' views on the training programme.

	Ghana		Ethiopia		Nigeria		Tanzania		Uganda		Kenya	
	T	*SL*	*T*	*SL*	*T*	*SL*	*T*	*SL*	*T*	*SL*	*T*	*SL*
Items	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
This event met my expectation	4.18 (.70)	4.34 (.62)	4.67 (.50)	4.64 (.54)	4.25 (.80)	4.04 (.80)	4.44 (.56)	4.55 (.54)	4.47 (.65)	4.41 (.62)	4.40 (.57)	4.49 (.59)
High quality event	4.22 (.62)	4.38 (.52)	4.49 (.63)	4.70 (.49)	4.31 (.67)	4.13 (.69)	4.41 (.57)	4.46 (.57)	4.44 (.68)	4.39 (.63)	4.09 (.92)	4.52 (.53)
Overall view on training	4.22 (.58)	4.36 (.48)	4.57 (.51)	4.67 (.42)	4.28 (.65)	4.09 (.64)	4.43 (.49)	4.51 (.50)	4.45 (.58)	4.40 (.52)	4.25 (.58)	4.51 (.49)

Note: 5 = strongly agree, 4 = agree, 3 = neither agree nor disagree, 2 = disagree, 1 = strongly disagree, T=Teachers, SL=School Leaders.

A two-tailed t-test performed between the perceptions of the teachers and school leaders did not show any significant difference between the two groups; an indication that the overall views with regard to the quality of the training and the training meeting participants' expectations were the same as perceived by teachers and leaders for all the participating countries. Similarly, an analysis of variance test showed no significant differences between the reported values across the countries; though the descriptive statistics showed that respondents from Ethiopia [*T* (Mean = 4.57, SD= 0.51) and *SL* (Mean = 4.67, SD= 0.42)] recorded the overall highest mean score whereas those from Ghana [*T* (Mean = 4.22, SD= 0.58)] and Nigeria *SL* [(Mean = 4.09, SD= 0.64)] had the least scores relatively for teachers and school leaders stakeholders respectively. Table 3 shows a summary of the results.

Data gathered from digi-hub ambassadors from the respective countries gave a better description of the nature of courses provided in the hubs during the project implementation period. Whereas some hubs achieved success in running most of the courses in the training manual, others focused on just a few of the courses. For example, in Ethiopia, all the 22 hubs focused on training on the theme "Basic ICT Skills and Microsoft Applications". Apart from two hubs which did extra courses in "Leadership Skills", the focus of all the other 19 hubs in Tanzania was on "Basic ICT Skills and Microsoft Applications". This pattern was similar in hubs in Kenya and Uganda. In Nigeria, apart from "Basic ICT Skills and Microsoft Applications", all the hubs focused on providing courses on "Professional Learning Networking" and "Using Internet Resources". The majority of the hubs in Ghana ran at least three or more courses in areas such as "Managing Change", "Leading Effective Teaching and Learning", "Goal setting for success", "Creating and Communicating a Vision", "Introduction to the Learning Suite – ICT Skills Development", "Team Working" etc. Thus, apart from "Basic ICT skills and Microsoft Applications" Ghana was the only country that appeared to have touched on all the courses proposed for the PD during implementation period.

A key observation made was that most hubs across the countries focused on training that equipped trainees with basic ICT skills acquisition and Microsoft applications. It is not too clear why the courses were limited to basic skills while a contributing factor reported by the digi-hub ambassadors was the issue of time. The digi-hub ambassadors' reports highlighted some challenges encountered during the training programme. Time for the training was generally limited in proportion to the package of training content for the training module. The quality of the internet connectivity was also heavily critiqued and frequent power failure was also detrimental to the overall quality of the training experience. In spite of these challenges, the training served as an eye opener as participants reported positive perceptions were also reflected in high ratings to recommend the programme to other colleagues (see Table 4). The overall ratings [*T* (Mean=8.91, SD= 1.98), *SL* (Mean=9.52, SD= 1.06)] were seemingly high for both teachers and school leaders.

Table 4: Teachers' ratings on recommendations of training programme.

	Teachers		School Leaders	
Country	**Mean**	**SD**	**Mean**	**SD**
Ghana	8.15	2.49	8.92	1.54
Ethiopia	9.52	1.06	9.57	0.87
Nigeria	9.00	1.82	8.71	0.92
Tanzania	9.09	1.50	8.99	0.68
Uganda	9.40	1.27	9.34	0.65
Kenya	6.58	3.17	9.54	1.50
Overall	8.91	1.98	9.31	0.56

Scale between 0-10; 0=very unlikely to recommend and 10= very likely to recommend

Professional learning

The second level of evaluation focused on the quality of the participants' learning in the training programme. Findings showed that school leaders' and teachers' perceptions about the impact of the training programme on their learning were positive. For example, all the participating countries reported an approximate mean (*SL*=3.74, *T*= 4.01) value of 4.0 (which is agree) for knowledge and skills acquired to integrate ICT in schools and teaching respectively (See Table 5); an indication that both school leaders and teachers had acquired the necessary knowledge and skills to use the digi-hubs in their professional practices. Similar trends were observed in knowledge and skills acquired by the trainees to support teachers and student learning (*SL*=3.76, *T*= 3.92) respectively and to promote or use the facilities in the digi-hubs (*SL*=3.75, *T*= 3.82). These findings bring into line the extent and quality of learning that took place by the trainees across the different participating countries.

Table 5: Knowledge and skills acquired from the training programme.

	Ghana		Ethiopia		Nigeria		Tanzania		Uganda		Kenya	
Lessons Learnt/ Acquired	*T*	*SL*	*T*	*SL*	*T*	*SL*	*T*	*SL*	*T*	*SL*	*T*	*SL*
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Knowledge and skills to integrate ICT schools/ teaching	3.98 (.23)	3.79 (.18)	4.06 (.50)	3.58 (.23)	3.77 (.24)	3.58 (.22)	4.29 (.41)	3.16 (.33)	4.05 (.39)	3.72 (.19)	3.92 (.14)	3.97 (.33)
Knowledge and skills to support teachers/students learning	4.06 (.19)	3.70 (.22)	4.06 (.32)	3.79 (.30)	3.71 (.21)	3.57 (.20)	4.12 (.20)	4.05 (.15)	3.93 (.43)	3.62 (.15)	3.68 (.19)	3.91 (.18)
Knowledge and skills to promote/ use facilities in the digi-Hub	3.89 (.13)	3.65 (.16)	4.06 (.36)	3.78 (.33)	3.59 (.37)	3.39 (.21)	3.99 (.28)	4.03 (.13)	3.87 (.20)	3.72 (.17)	3.83 (.28)	3.91 (.20)

Note: 5= strongly agree, 4=agree, 3=neither agree nor disagree, 2= disagree, 1=strongly disagree; T=teachers, SL= School Leaders

The report on the overall means (see Figure 1) of the measures used in assessing the quality of the participants' learning also confirmed that school leaders and teachers acquired significant knowledge and skill through the training programme. From Figure 1, the overall mean scores (*SL*=3.84, *T*=3.95) of lessons learnt by respondents from all the countries seemed satisfactory and give an indication that the training programme impacted on both the school leaders' and teachers' learning.

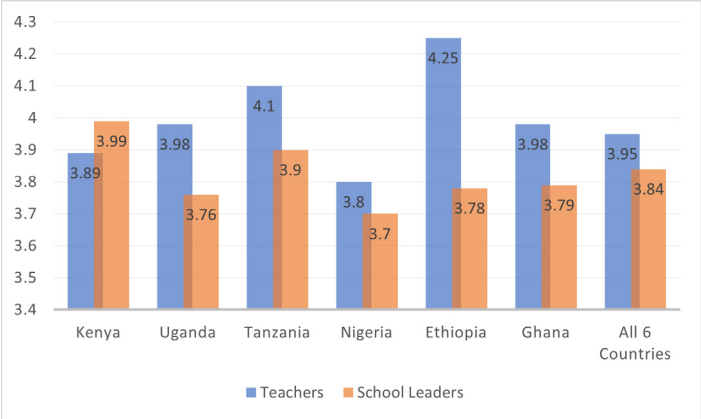

Figure 1: Country by country overall lessons learnt.

Interestingly, among the six countries, teachers (*T* = 4.25) in Ethiopia and school leaders (*SL* = 3.99) in Kenya reported the highest positive perceptions about knowledge and skills gained in the training programme, while Nigeria (*SL* = 3.7, *T* = 3.8) reported the least for both teachers and school leaders.

Organisation support or institutional conditions

To explore practices and school conditions that underpin or support teachers' implementation efforts and recognition of the digi-hubs in teaching, learning and school organisation, the survey required school leaders and teachers to determine if they have any plans in place of how they will use ICT in their professional practices in the future and explain three things they would like to do or change as a result of the training. Responses of the trainees showed highly positive perceptions on plans in place to use ICT in their teaching and school organisations. Averagely, all countries reported fairly high responses (see Figure 2). The average scores of 4.09 for teachers and 4.14 for school leaders indicate the participants' willingness to transform teaching, learning and organisation of schools with ICT in their respective countries.

Regarding what exactly participants will want to do or change as a result of the training programme, they enumerated various things. Table 6 presents the categories of teachers' responses on what they would want to do while Table 7 displays that of the school leaders. What was most popular among the teachers was the drive to motivate and help other teachers to integrate ICT in their teaching (17%). The next most popular was promoting curriculum reform and development (15%).

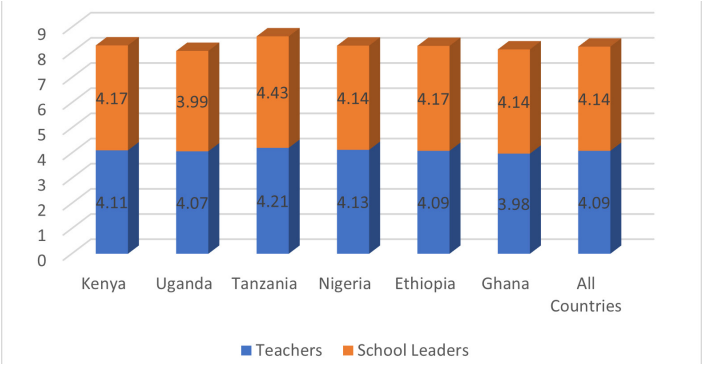

Figure 2: School leaders' and teachers' future plans to use ICT.

Table 6: Teachers' views on support of ICT implementation.

Description	% Response
Motivate and help other teachers integrate ICT	17
Curriculum reform/Development	15
Advocate for ICT facilities provision in schools to enhance T & L	14
Adopt new approach to teaching with ICT	12
Change personal attitude	10
Motivate students to use ICT	10
Promote student-centered approach of teaching	8
Networking	6
Advocate for training for teachers	1
Others	7

What was most popular among the leaders was a desire to motivate students to use ICT (18.5%) followed by improving their professional leadership skills (16.7%). Similar to the findings with the teachers, the school leaders also expressed a high desire to motivate teachers to use ICT to teach (12.6%). The distribution of responses by themes is shown in Table 7.

Table 7: School leaders' views on support of ICT implementation.

Description	% Response
Motivate students to use ICT	18.5
Improve my professional leadership skills	16.7
Motivate teachers to use ICT to teach	12.6
Improve schools' vision	11.0
Infrastructure development/support	10.2
Organisation of ICT-based in-service training for teacher	8.4
Involving teachers and all stakeholders in decision making	7.9
Promote commitment of teachers	6.8
Promote team work of teachers	4.4
Others	3.7

Use of new knowledge and skills

A major question dealt with in the study was whether the school leaders and teachers were able to transfer their knowledge and skills gained in the capacity building programme to school organisations and curriculum practices. Records from the digi-hubs provided evidence to this extent. The majority (37.6%) of teacher respondents used the hub to explore ICT applications such as presentations and spreadsheet while quite a good number (26.9%) also used it mainly for research work.

Table 8: Overall teachers' usage of the digi-hub.

Description	% Response
To use an application, e.g. spreadsheet, presentation	37.6
For research work or personal use	26.9
To communicate with others in another school via internet	17.4
To present something to my students in the digi-hub	7.4
For my students to research a subject on the internet	4.9
To find/create material to use with my students in the classroom	3.7
To find/create material to use with my students in the digi-hub	2.2

The use of new technology to support cross-curricular classroom practices comes out strongly as reported in relatively low percentage teacher responses for items such as: *To find/create material to use with my students in the classroom* (3.7%) and *To find/create material to use with my students in the digi-hub* (2.2% – see Table 8). The digi-hub records further showed the diverse ways the Hubs have been used by schools and their extended communities as reported by school leaders. They indicated using the Hubs to train community members to acquire basic ICT skills, accessing emails where there is connectivity and preparing reports. Some of the countries (Nigeria, Tanzania, Kenya) used the Hubs to train parents on ICT skill acquisition while others (Ghana, Kenya) used the Hubs as training centres for children from the community. Uganda had plans to train soldiers within the barracks on basic skills in computers. Ghana used the Hubs to train District Education officers while Ethiopia trained Educational Bureau Officials on ICT basic acquisition.

Thus, the results here seem to suggest that school leaders were most comfortable with aspects of digi-hub training linked to basic ICT skills acquisition because it promoted their own professional practices and helped them to extend the training to community members in diverse ways across the countries. Transfer of knowledge and skills by the teachers on the other hand required more than the mere inclination to use ICT tools; it needed more of an appreciation of the complex set of interrelationships between tools, users and teaching practices which was barely observed. Apparently, the training programme lacked dimensions for skill and knowledge development for exploring and examining how technology can be integrated with pedagogy and content to enhance teaching and learning strategies in their subject or classroom teaching. This could be the possible reason that explains the teachers' inability to transfer their acquired ICT competency from basic technology literacy to infusing level.

Discussion

The study followed up on a project in which digital hubs were installed and made operational in schools from six Sub-Saharan African countries, namely Kenya, Tanzania, Uganda, Ethiopia, Ghana and Nigeria. One major aim of the project was to build capacity of school leaders and teachers by providing PD or training courses in order to support them to embed ICT into school organisation and curriculum practices. This study reports on the impact of the PD programme: the quality and extent of transfer of the programmes' ideas from the school leader and teacher stakeholder's capacity building to school organisation and classroom implementation. Results of the study showed that the majority of participants across the six countries expressed general satisfaction with training content and processes. The evidence as confirmed in the self-report data suggests that the training programme was of a high quality and developed the teachers' knowledge and skill mainly in applying and infusing ICT in their professional practices and learning networks.

It was encouraging to note that the participating school leaders and teachers appeared generally supportive and confident in wanting to use ICTs in their school organisations. Their overwhelming high perceptions to integrate ICT in innovative ways were not limited merely to developing their own personal practices and professional learning networks, but to improve teaching in their future lessons, enhance students' learning and promote curriculum reform and development as well are worth mentioning. What was most popular among the stakeholder groups was the drive to motivate and help other teachers to integrate ICT in their teaching; the respondents indicated that they will impart knowledge acquired to other teachers, share with colleague teachers what they have learnt and encourage fellow teachers in their schools to embrace ICT use. Thus, it suffices to say that the PD programme achieved some success in developing teachers' high positive perceptions and stimulating the participants' interest in ways that could encourage future uptake of ICT integration in spite of its limitation in providing adequate opportunity for the teachers to develop pedagogical integration of ICT experiences (cf. Webb & Cox, 2004). This finding seems to align with several studies (Meelissen, 2008; Paraskeva et al., 2008) which report positive attitude as a necessary condition for predicting teachers' future classroom integration and acceptance of technology (Agyei & Voogt, 2012). The finding can also be explained by the assertion of Todorova and Osburg (2009) that professional development programmes aiming to realise the sustainable uptake of ICT in teaching and learning can only be successful based on the two main factors. Thus, when participants involved develop positive attitudes and are satisfied with the programme and when the reason for using ICT to improve teaching and learning practices is accepted by the entire school organisation and not only by those who participated in the programme. Clearly, the result here suggests that the school leaders and teachers who participated in this study developed high tendencies of promoting and implementing ICT in their future classrooms since they seemed enthusiastic about plans and conditions they needed to put in place to support their ICT implementation efforts; an indication that the PD imparted positively on them.

Notwithstanding the positive high perceptions reported, participants faced some challenges during the training programme. Across all the countries, the critical area for improvement that was most commented on by participants during the training course was related to the issue of time. It appears the time for the training course was limited in proportion to the package of the training workshop modules. As a result, there was not enough time for practice of ICT basic skills for understanding, application and infusion of ICT concepts and resources in school and classroom practices. This confirms a number of studies which reiterate

that the adoption of innovation takes time (Agyei, 2013; Ebersole & Vorndam, 2003; Fullan, 2007). As Ely (1999) explained, implementers of an innovation must have time to learn, adapt, integrate, and reflect on what they are doing. It takes time for the people to understand the innovation and develop the abilities to adapt the innovation.

Apart from the self-reported data, a review of the training programme as recorded in reports by the Digital Ambassadors also showed some shortfalls which when corrected could enhance the quality and impact of the programme. Apparently, being novices in ICT use in education, the participating school leaders' and teachers' judgements on the impact of the training programme were limited to their understanding of what they believed was entailed in embedding ICT in school and classroom practices; this might have accounted for the high scores of their self-report data. Thus, though the study showed evidence that the training participants developed their knowledge and skill to use the digi-hubs across the participating countries, this was limited to using basic ICT applications to enhance their own practices and their professional learning networks as mentioned earlier, and not so much of teachers' classroom implementation of ICT which results when transfer of learning takes place from training to practice.

The findings here seem to suggest that the PD programme lacked more in-depth approaches in imparting knowledge and skills to participants to explore how technology can be integrated in school organisation and classroom practices. Baylor and Ritchie (2002) have indicated that training has an important influence on how well ICT is embraced in the classroom. Redmond (2007) and Kelz (2011) have also indicated that if teachers are not trained or prepared sufficiently for their new roles with technology, then it could be that they merely will try to transfer their classroom practices to the new environment. Thus, the study has shown that there is a need for governments in Sub-Saharan Africa to emphasise effective PD as key to implementing ICT initiatives, policies and curricula in an attempt to enhance teaching and learning with ICT. A PD arrangement in this regard, therefore, should seek to ensure that there are enabling conditions that will bring about ICT adoption and pedagogical change across component of school systems, curriculum and instruction. According to Fishman and Krajcik (2003), such PD approaches should seek to create a lasting change with technology that have sustainable impact on teaching and learning; thus, in designing effective professional training initiatives, designers should seek to incorporate innovations that function as part of systemic reforms. Fishman and Krajcik (2003) indicated that a fundamental goal of systemic reform is alignment across component of school systems (such as administration and management, curriculum and instruction, assessment and policy). The author, therefore, argues that for effective preparation of school leaders and teachers in order to transfer ICT knowledge and skill acquired, there is a need to include in training programmes contents that will build trainees' competency more incrementally from their own personal practices and professional learning networks into infusing ICT into the school organisation and curriculum practices even when the training is over.

Limitation

The study was not without limitations. The fact that the study did not make use of observed data to verify conditions of implementation of the training ideas at the school levels was a hindrance to the study. As a result, transferability of ideas of the training programme was limited to records of data collected at the various local hub settings and reported perceptions of what school leaders and teachers said they will do or have done. The author recognises that though self-report data provide important information about an individual's ICT knowledge and skill awareness, they are limited to measuring individuals' beliefs and not so much of what they can actually do or did. The limitation notwithstanding, this study allows for broad generalisations of the findings to Sub-Saharan African regions and similar context. Evidence from the study did not seem to differ significantly among the different stakeholder as well as the different participating countries; apparently, the contexts and conditions under which the study was conducted were similar across the participating countries.

Practical implications

The study has demonstrated that both school leaders and teachers increased their ICT proficiencies. However, it was limited to their own PD and learning networks and not so much on transfer of professional learning from training programmes to school and classroom implementation. Again, outcomes of the study showed that the participants expressed general satisfaction with training content and processes of the PD training programme; yet essential conditions to support transfer of the trainings' ideas to school level were seemingly not adequate during the period of implementation. Consequently, the study highlights areas that require further attention to enable school leaders and teachers infuse ICT into transforming school practices. In particular, elements of a PD scenario that will assist school leaders and teachers develop and transfer skills in ways to integrate ICT to bring about sustainable impact on teaching, learning and school organisation are discussed. In replicating such an arrangement, particularly in the Sub-Saharan region and similar contexts, programme designers should deliberately create professional learning experiences in which the following characteristics identified in the PD programme will be observed:

- Build a PD model into a more comprehensive framework that will assist school leaders and teachers to develop knowledge and skills about the use of ICT to support pedagogy, content and school organisation and management. The framework could incorporate a more systematic and graduated process for ICT competency development from basic ICT skills to technology literacy skills to skills for ICT infusion in school organisation and classroom practices.

- Build on the professional development activities to include – school level specific and subject specific elements that take into consideration the context of the stakeholder population of school leaders and teachers.

- Encourage modeling through demonstrations and exemplary materials on how to use technology as a component of the professional development. Exemplary curriculum materials are an important means as they can inspire both school leaders and teachers to learn and provide a better understanding of what ICT integration can look like in professional practice.

- Build in scaffolding and authentic technology experiences (such as teaching try-outs).
  as an integral part of the professional development programmes - Teaching try-outs have the tendency to reduce anxieties about ICT thereby increasing trainees' enthusiasm to use ICT in practice.

- Build in sufficient time in course delivery to ensure that school leader-teacher target populations have adequate time and opportunities to develop and apply their ICT competencies (e.g., from ICT basic to technology literacy to infusing levels).

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Early mathematics learning among naturalised refugee citizens and rural majority and urban majority groups in Tanzania

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Abstract

Globally, available empirical evidence has consistently indicated children of immigrants and refugee backgrounds lagging in most of the developmental indicators and early achievements and learning tests. The developmental and learning disparities are more nuanced in the sub-Saharan region which is characterized by reportedly limited educational resources. This article discusses mathematics learning environments during early years education among naturalized citizens/refugees in Tanzania. Their early mathematics attainments are observed on a benchmark of children from other groups such as urban and rural majorities. The article delineates the role of home learning environments and family socioeconomic status by linking global perspectives and findings from the sub-Saharan region to that from Tanzania. It further discusses the context of early mathematics learning in Tanzania, the existing gap in policy, research, and practice. Challenges facing children of naturalised citizens in learning mathematics within the Tanzanian education system are also discussed. The noted challenges include issues related to curriculum, cultural practices and parental beliefs, mastery of Kiswahili – the official early grades medium of instruction in Tanzania, financing, and quality of early grades mathematics teachers. The article concludes by arguing for improvements in learning experiences of all learners regardless of backgrounds, race, gender, and/or citizenship status. Recommendations for policy, practice, and future research related to children from immigrant and refugee backgrounds are made.

Introduction

The body of available empirical evidence has consistently indicated that the quality of children's home learning environment and their family socioeconomic status (SES) can adversely affect their development and learning outcomes (Ip et al., 2016; Kiernan & Mensah, 2014; Melhuish et al., 2008). The resulting inequality is said to persist from early childhood to adulthood (Shonkoff & Phillips, 2000). It is reported to have a more deleterious impact on children from poor families who live in rural areas (Ndijuye, 2020). Comparatively speaking, it has an even more severe impact on rural children of immigrant and refugee backgrounds (Koury & Votriba-Drzal, 2014; Kuch, 2017; Ndijuye & Rao, 2018, 2019).

For many decades, early years education researchers have placed great emphasis on the dominant role played by cognitive skills in their research on educational and social inequality (Jones et al., 2015; Koury & Votriba-Drzal, 2014). However, more recent findings have consistently indicated that early academic skills provide a foundation for ongoing engagement in learning throughout schooling (Magnuson et al., 2016), for cognitive skills at the pre-primary and grade one entry levels are strong predictors of later academic achievement (Reardon & Portilla, 2016) and have been found to predict earnings later in life (Heckman, 2011; Heckman et al., 2018).

This study conceptualises children's readiness for school in terms of how well the surrounding environment of children five to eight years of age supports their optimal development and learning. Specifically, the focus is on the development of numeracy skills which align with the existing primary school curriculum. As such, school readiness is expected to broadly promote children's development while simultaneously supporting their respective families (Kagan, 2006; Reardon & Portilla, 2016).

The role of home environments and family SES on children's mathematics attainment

Globally, empirical evidence has consistently indicated linear relationships between home learning environments, family socioeconomic status and children's mathematical skills (Black et al., 2016; Ndijuye, 2020; Reardon & Portilla, 2016). Early mathematics has been proved to be a strong predictor of later academic achievement (Duncan et al., 2007), attention skills (Melhuish et al., 2008), and adult life success (Heckman et al., 2018). In developed countries, research has consistently indicated that children from socio-economically poor and minority immigrant households either come to school with or demonstrate poor mathematical skills (Leyva et al., 2019; Reardon & Portilla, 2016). Little is known in this respect with regard to the sub-Saharan region.

The available cross-cultural studies have indicated that early numeracy experiences at home influence children's acquisition of mathematical skills (Melhuish et al., 2008; Leyva et al., 2019). The learning support noted may be in the form of active parent–child interaction, frequency of engagement, play, the naming of various objects and the presence of print materials at home (Ip et al., 2016; Melhuish et al., 2008; Ndijuye, 2020). Additionally, the noted aspects help to demonstrate the existing effect size relative to family wealth and socioeconomic status (Ndijuye, 2020). Given the increasing attention paid to the development of early mathematical skills (Leyva et al., 2019; Ndijuye & Rao, 2019), it is important to examine the home context specifically with regard to early mathematics to better understand the mechanisms of development.

In sub-Saharan Africa where there are limited educational resources, the home learning environment and a relatively high family SES are two determinant factors in children's learning and development (Matafwali & Chansa-Kabali, 2017; Ndijuye, 2020). Supportive environments fill the gap left by low-quality schools and teachers (Sumra & Katabaro, 2015; UNESCO, 2020). In Tanzania for instance, children's higher learning attainments have been associated with supportive home learning environments and higher family SES (Kafle et al., 2018; Ndijuye & Rao, 2019; Uwezo, 2020). This is particularly important, and evident, among sub-Saharan children from rural immigrant and refugee communities or backgrounds who are registered at schools with limited educational resources (Kuch, 2017; Ndijuye & Rao, 2019).

Family socioeconomic status is defined by family wealth or income, parental education – especially maternal education, quality and frequency of caregiver–child interaction and parental occupation (Bradley et al., 2001; Ip et al., 2016). Some empirical evidence indicates that, due to the parental stress and hardships associated with economic hardships, children of refugee backgrounds with a lower SES have experienced hostile parenting and poor child management (Kuch, 2017; Mitchell & Kamenarac, 2021). In comparative terms, children from families with a lower SES are less likely to engage in mentally and physically stimulating learning activities such as museum or theatre visits or to benefit from having parental verbal responsiveness, high frequency parental reading and counting of objects available in their surrounding environments, and they are more likely to have poorer physical home characteristics (Engle et al., 2012; Ip et al., 2016; Ndijuye, 2020).

Family SES has been associated with children's cognitive development and mathematical skills (Bradley et al., 2001; Heckman, 2011). Children with a lower family SES have been found to demonstrate poorer cognitive development and mathematical skills than those with a higher family SES (Weiland & Yoshikawa, 2013). The disparities are said to have implications on children's holistic development (Murphy et al., 2018) and income later in life (Heckman et al., 2018). Over the decades, findings from both developed and developing countries have consistently indicated that every increase in family SES results in increased resources and opportunities for child development and learning outcomes (Bradley et al., 2001; Kafle et al., 2018; Lee & Al Otaiba, 2015) and that the impact is greater among immigrant families (Ndijuye, 2020). In developed countries, most of the existing job opportunities are in fields related to science, technology, engineering and mathematics (STEM), but children from lower income and refugee backgrounds are falling behind in STEM-related subjects (Blums et al., 2016). For instance, in the United

States, evidence from various studies (see Blums et al., 2016; Heckman, 2011; Reardon & Portilla, 2016) consistently indicates that the 90/10 income achievement gap has been growing since the 1970s, according to which children from lower-income households score an average of 1.25 standard deviations lower on standardised mathematics tests than those from higher-income households (Reardon & Portilla, 2016). Note that the percentile measures families at the 90th percentile of the national family income distribution against those at the 10th percentile of national family income.

In the sub-Saharan region, and Tanzania in particular, the available empirical evidence indicates that children from lower SES families demonstrate poor learning and developmental outcomes, including in mathematics (Ndijuye, 2020; Rawle, 2015; UIS, 2021; Uwezo, 2020). There are huge gender and urbanicity divides in early mathematics achievement, with urban boys outperforming rural girls by more than 2.3 points of standard deviation (NECTA, 2020; Uwezo, 2020). As far as mathematics learning outcomes are concerned, being a girl from rural Tanzania equates to a double disadvantage. Despite such associations between early SES and later school achievement in Tanzania, our knowledge about how family socioeconomic status (SES) effects are instantiated remains limited.

Education system and provision in Tanzania

The United Republic of Tanzania (URT) follows the 1(2)-7-4-2-3+ formal educational model. This includes one (or two) years of pre-primary education, seven years of primary level education and four years of lower secondary school level education. The pre-primary to lower secondary levels comprise the compulsory component of basic education in Tanzania. The two years at the upper/high secondary level and three or more years at the tertiary level are a necessary element of formal education but they are not compulsory (URT, 2014).

Kiswahili is a medium of instruction in public schools from the pre-primary to the primary school levels, while English is used from lower secondary school on to the tertiary levels (MoEST, 2018; URT, 2014). Given the poor planning of language transition between the primary and secondary school levels (Qorro, 2013) and the poor quality of teachers (Sumra & Katabaro, 2014), there is a sharp decline in secondary students' academic performance. Comparatively speaking, performance is poorer in mathematics among secondary school students (MoEST, 2020) than at any other level of education or in any other field of study.

In 1992, Tanzania formed a national task force for the first time to develop what became the comprehensive Education and Training Policy (ETP) in 1995 (MOEC, 1995). According to this policy, pre-primary education for five- and six-year-olds was attached to primary education and declared the government's responsibility (URT, 1995). The reform sought to increase access to pre-primary education and link it with primary education by requiring that each primary school start a pre-primary class (URT, 1995). While this approach may have increased access to services, the downward extension of primary education negatively affected the quality of services (Ndijuye & Rao, 2018). Various syllabi catering to this age cohort were developed in 1999, 2000 and 2005, and the state appeared to be trying to catch up with the rest of the world and preparing its young children for the 21st century (URT, 2014).

In 2000, in response to the Education For All (EFA) monitoring report, responsibility for the well-being and education of children from birth to four years was given to the Ministry of Community Development, Gender and Children. Connected to this was the Dakar Framework of Action (2000), which intensified the world movement toward provision of education as a human right. By stressing equitable access to high-quality education, the chances of more Tanzanian children being able to do so, regardless of their backgrounds, increased – at least on paper.

Due to the liberalisation policies of the late 1980s and early 1990s in Africa, the period from 1995 to 2000 saw a decline in public school enrolment due to the introduction of cost-sharing in education (Ndijuye, 2020). Economically better-off parents sent their children to private pre-primary and primary schools, which were equipped with more educational resources. Due to poor physical infrastructure and declining teacher quality, most children, especially in rural areas, were going to school but not necessarily learning at their grade levels (Uwezo, 2010, 2014, 2020). Various studies reported that the majority of children were finishing the primary education cycle without mastering basic numeracy skills (Ndijuye & Rao, 2018, 2019; NECTA, 2020; RTI, 2014; Sumra & Katabaro, 2015; UIS, 2021; Uwezo, 2015) and that some of these semi-illiterate pupils were later enrolled in secondary schools, only to drop out part-way through the school (Sumra & Katabaro, 2015). It was under such circumstances that education stakeholders in the country rallied against the existing policy in favour of a new one that targeted not only broadening educational opportunities but also the quality of those opportunities.

With rapid economic growth and social change in Tanzania and technological advancement throughout the world, by 2010 it was obvious that Tanzania's existing education policy was not bringing about the desired results. As such, educational practitioners started to argue in favour of changing the education policy to meet new demands. In February 2014, the new Education and Training Policy (ETP) was launched for implementation in financial year 2015 (URT, 2014). The new policy seems to target increased access to education without compromising the quality thereof and to focus on issues related to inclusiveness, class size, improved teacher training and attrition (MoEST, 2018). Although children of naturalised citizens are entitled to access to compulsory and free basic education, the performance of this minority group has not been well documented (Kuch, 2017; Ndijuye & Rao, 2018, 2019; Ndijuye, 2020). Data on this subgroup has not even included in the official government's Basic Education Statistics (BEST) until recently (MoEST, 2018).

The existing gap in early grades mathematics attainment in Tanzania

The academic and non-academic achievement gap between children from rich majority and poor immigrant and refugee backgrounds is an area well researched among education scholars (Bethell, 2016; Bradley et al., 2001; Heckman, 2011; Ip et al., 2016; Ndijuye & Rao, 2019). Globally, the mathematics achievement gap is said to start forming even before children begin pre-primary education and persists throughout their academic lifetime and beyond (Bethell, 2016; Han et al., 2012; UIS, 2020). In the sub-Saharan region, even after interventions, the attainment gap widens as children progress to the upper grades (SACMEQ, 2020; Uwezo, 2020). In this region, the most disadvantaged group is rural girls of refugee backgrounds from poor households (Kuch, 2017).

In Tanzania, the mathematics achievement gap among early grades children is one of the least-documented research areas (MoEST, 2020; Ndijuye & Rao, 2019; Ndijuye, 2020; SACMEQ, 2020; Uwezo, 2020). Over the past 20 years, Tanzania has made many efforts to broaden access to basic education (United Republic of Tanzania, 2014; UIS, 2020). However, these efforts have tended not to take account of the quality of education provided, especially for children from marginal groups such as those of refugee backgrounds (Ndijuye & Rao, 2018; RTI International 2020). The most recent independent numeracy assessment tests for early grades children have indicated a sharp decline among children of refugee backgrounds compared to those from non-refugee groups (Ndijuye & Rao, 2019; Rawle, 2015).

Findings by Uwezo (2015 to 2020) indicate that while Tanzania has achieved almost universal access to basic education, most rural children are just "schooling" and not learning to their respective grade levels. For example, in 2020, about 10.1 percent of children aged 5–6 years were not in any form of schooling, even though the official Education and Training Policy requires that all children of this age must be enrolled at pre-primary school level (URT, 2014). About 72 percent of early grades children cannot do word problem subtraction, while for the middle grades this figure is about 43 percent. Similarly, among middle grades children, only 33.4 percent can perform numeracy operations at division level. Surprisingly, among children of refugee backgrounds, about 64 percent in grade four can perform a grade two mathematics exercise, while about 67 percent can perform division-level mathematics.

Generally speaking, early mathematics attainment in Tanzania has been sharply declining for decades (Humble & Dixon, 2017; Ndijuye, 2020; NECTA, 2020; Rawle, 2015) compared to neighbouring countries in the region with a similar socioeconomic status. For instance, the SACMEQ (2020) results show Tanzania's fourth grade children as performing significantly above the 404 averages, but when they are compared to the TIMSS (2011) results, Tanzania's fourth grade children performed far below their fourth grade counterparts in countries beyond the sub-Saharan region, who had between 516 to 600 average points. If one looks closely at their performance against the absolute levels of achievement within the SACMEQ framework, the findings are even less optimistic.

On average, 44 percent of fourth grade children are classified as innumerate, with this figure rising to more than 62 percent in rural areas. Findings by Uwezo (2020) indicate that in Tanzania, children from upper quartiles of the SES outperform their less advantaged peers by a statistically significant margin. There was a relatively large gender divide in early numeracy learning attainment in Tanzania, with boys outperforming girls (NECTA, 2020; Ndijuye; 2020; Uwezo, 2020). Regardless of cultural differences and parental beliefs and expectations, the gender divide is evident even among naturalised citizens (Ndijuye & Rao, 2019). The reasons for the gender divide in early numeracy attainment are not yet empirically known.

One of the notable challenges facing early numeracy attainment in Tanzania is the quality of the national education system and, therefore, the quality of the country's schools. The key challenge is the limited number of high-quality early grades teachers (MoEST, 2020; Ndijuye & Rao, 2019) and the limited educational resources (Rawle, 2015). The most challenging aspect of the problem is that even the few qualified teachers that are available are concentrated in urban areas (MoEST, 2020). Given that children of refugee backgrounds live and study predominantly in rural areas of Tanzania, this is likely a problem that they face.

Contexts of naturalised refugees/citizens in Tanzania

Since 1961, Tanzania has hosted over 3 million refugees from neighbouring countries (Tanzania Ministry for Home Affairs, 2020). About 300,000 of these have been naturalised as Tanzanian citizens (MoHA, 2020; UNHCR, 2020). Naturalised citizens of refugee backgrounds are mostly from Burundi (82 percent), Somalia (8 percent), the Democratic Republic of Congo (4 percent), Rwanda (2 percent), Mozambique (1 percent) and others (3 percent) (MoHA, 2020). This study will focus on mathematics learning attainment among the children of naturalised citizens of Burundian origin and their families in Tanzania.

Until 2020, there were about 437,140 naturalised citizens of Burundian origin living in Tanzania (MoHA, 2020). They live predominantly in former refugee camps, currently called settlement areas and located in Mishamo, Katumba and Ulyankulu in western Tanzania. The others lead independent lives alongside rural local majorities in the Kigoma region as self-settled naturalised citizens (MoHA, 2020; Ndijuye, 2020). In 2020, about 12,614 of these naturalised citizens were children 5 to 8 years old and registered at various schools for pre-primary to grade two (MoEST, 2020). In the same year, there were 56 qualified early grades teachers working in public primary schools in the settlement areas.

Recent national early numeracy assessment tests (NECTA, 2020; RTI International, 2014; Uwezo, 2020) and empirical studies (Ndijuye & Rao, 2019) in Tanzania indicate that children of naturalised citizens of Burundian origin were not just schooling but learning far better than their rural majority counterparts. Their higher attainment was presumed to be

associated with parental beliefs and expectations (Ndijuye, 2020; Ndijuye & Rao, 2019) and with improved family living standards and SES (Uwezo, 2020).

In Tanzania, existing evidence documents the achievement gaps between rural and urban children (Ndijuye & Rao, 2019; Rawle, 2015; RTI-International, 2014), the genders (Mwaura et al., 2008; Uwezo, 2020) and marginal districts within the mainstream education system (Mwaura et al., 2008; Rawle, 2015). While the achievement gaps among and between naturalised citizens and refugees in the sub-Saharan region are under-studied, to the best of our knowledge there is no single study which focuses exclusively on early mathematics learning and existing gaps among naturalised citizens in Tanzania.

Factors affecting naturalised citizens' early mathematics learning in Tanzania

Curriculum issues

Mathematics learning is a central and fully recognised subject of study in the current school curriculum of Tanzania. It is a compulsory core subject from the pre-primary level – where it is taught in a form of emergent numeracy – to the lower secondary levels (URT, 2014). The importance of mathematics is also reflected in the time dedicated to its teaching, which is comparable to that allocated in more developed systems and, in some cases, exceeds international norms (Bethell, 2016; RTI International, 2020). Over the past 20 years in Tanzania, the mathematics curricula have been revised and modernised as part of broader educational reforms emphasising movement towards competency-based curricular models. In fact, however, early grades mathematics curricular and classroom practices in Tanzania remain largely defined by content and are often delivered by teacher-led pedagogies (Ndijuye & Tandika, 2022).

At the outset, the content of the primary level curricula, for instance, corresponds to widely accepted theories of the development and acquisition of mathematical concepts and appears to be closely aligned with that found elsewhere (Tanzania Institute of Education, 2020). At this level at least, the fundamental problem does not appear to be in the content of the intended curriculum but in its delivery. The available body of empirical evidence suggests that across Tanzania, teachers are failing to help learners grasp the basic concepts of numeracy (see RTI International, 2014, 2020; Uwezo, 2020). This failure has implications for children's learning achievement in mathematics at higher levels (Humble & Dixon, 2017) even later in life.

Further evidence from Tanzania indicates that, beyond the primary level, the current curricula are not well aligned to the needs and abilities of learners from minority backgrounds including the children of naturalised citizens of Burundian origin (Ndijuye, 2020; Uwezo, 2020). As such, the curriculum as delivered is dominated by high stakes requirements and the existing national examinations are used to select students for the next levels and further educational opportunities (NECTA, 2020; Sumra & Katabaro, 2015). In recent grade seven results, which marks the end of primary education, the failure rates for mathematics when compared to other subjects are extremely high (NECTA, 2016, 2017, 2018, 2019, 2020). These examination results suggest that mathematics teaching strategies are ineffective and perhaps reveal great inefficiencies in the current education system. For example, in Tanzania in 2019, of the roughly 612,000 pupils who sat for the primary school leaving examination in Basic Mathematics, only some 83,000 were successful, for a pass rate of around 13.6 percent (NECTA, 2020). In the same examination, children from rural areas performed much worse than those from urban areas, with only 8 percent scoring a grade B or above.

Cultural issues and parental beliefs

The exceptional gains and effective mathematics teaching and learning found in East Asia suggest that the culture in which teaching and learning take place may offer the most critical explanation as to why some educational systems lag behind (Bethell, 2016). Recent studies have documented the following: societal value attached to education, general perceptions of the difficulty of mathematics as a subject, and parental beliefs and the prevailing view among teachers about the nature of mathematics and how learners acquire true understanding of mathematical concepts (Jerrim, 2014; Lee et al., 2017; Ndijuye, 2020; Weiland & Yoshikawa, 2013). In Tanzania, the general cultural belief about mathematics is that it is a very difficult subject reserved for a few talented learners (Bethell, 2016; Ndijuye, 2020). There are huge gender differences in mathematics learning outcomes, with girls underperforming in examinations across all levels of education due to cultural factors (Ndijuye, 2020; RTI International, 2020; Uwezo, 2020). Various empirical findings suggest that the majority of parents possess culturally conditioned mixed views of mathematics (Mazana et al., 2020; Ndijuye & Rao, 2019).

It is important to note that schools in Tanzania and other parts of the sub-Saharan region tend to reflect the cultural values of the societies they serve. In such contexts, the education of girls is seen as less important than that of boys (Ndijuye, 2020). Given a choice of who to send to school, most of the parents would choose to send their sons due to the lower expectations they have of their daughters. This is a view shared by teachers who, in general, tend to have a better opinion of their male students and, consequently, pay less attention to the girls in their classes (Bethell, 2016; Rabiner et al., 2016). Such prejudice coupled with the low expectations of society has a negative impact on the self-confidence of girls. Sadly, the implications of this for girls' mathematical performance are particularly damaging and on a large scale (Bethell, 2016; Humble & Dixon, 2017; Mazana et al., 2020; Ndijuye & Rao, 2019; Rawle, 2015).

However, among naturalised citizens in Tanzania, the most recent research findings indicate that parents had high regard for education in general and mathematics in particular (Kuch, 2017; Ndijuye, 2020; Ndijuye & Rao, 2018, 2019). Parents regarded education as a pathway to higher social status (Ndijuye & Rao, 2019) and as an escape route from intergenerational poverty (Ndijuye, 2020). As such, they reported employing various strategies to ensure that

their children were not just schooling but learning to their grade levels and beyond. These strategies include sending their children to attend church sermons so as to master the language of instruction, which is different from the official medium of instruction (Ndijuye & Rao, 2019), limiting children's use of vernacular languages at home (Center for the Study of Forced Migration (CSFM, 2008) and added home assignments (Kuch, 2017).

The influence of parental beliefs and expectations on children's early mathematics attainment has been found in other contexts (Lee et al., 2017; Thanh-Pham & Renshaw, 2015). In the United States, children of Asian origin have consistently achieved higher mathematical-learning attainment than the local majorities and other immigrant groups (de Brey et al., 2019; Ng & Wei, 2020; OECD, 2016). Existing empirical evidence has documented the Asian children's higher mathematical attainment, showing the influences of their Confucian heritage culture on parenting (de Brey et al, 2019; Ng & Wei, 2020), behaviour and thinking (Shin, 2012), and teaching and learning approaches (Lee et al., 2017).

Cultural and ethnic differences have been documented as influencing mathematical learning attainment of, among and across immigrant population groups (de Brey et al., 2019; Ndijuye, 2020; Ng & Wei, 2020). While in Europe, immigrant children of Asian origin have not shown any significant differences in early learning attainment compared to other immigrants and/or local majorities (Passaretta & Skopek, 2018), in the United States, they have consistently indicated higher learning attainment from preschool to university (Kim et al., 2016; Ng et al., 2017). Even across the sub-Saharan region, not all immigrant children have demonstrated higher learning attainment than local majorities (Dubeck et al., 2012; Piper et al., 2020). For instance, compared to local majorities, refugee children living in the Kakuma camp in Kenya have demonstrated concerningly lower learning attainment. The overall mean score for refugee children was even lower than for children from the disadvantaged Turkana local majority (Piper et al., 2020).

These findings call for active family involvement, including parental beliefs and practices that can positively influence children's learning and development (Garvis, 2021; Selin, 2014). For instance, immigrant Chinese parents in the United States have higher academic expectations of their children to the extent that any score below A+ is mockingly referred to as an Asian F (Ng et al, 2017; Ng & Wei, 2020). Parental beliefs, expectations and involvement have been found to be vital within the context of limited educational resources and large learning disparities across urban–rural, family socioeconomic status and gender divides (Ndijuye & Tandika, 2022) typical of the sub-Saharan region (Bethell, 2016; UIS, 2021).

Mathematics teacher quality in Tanzania

Empirical and grey evidence indicates that effective, high-quality early years mathematics teachers influence children's acquisition of basic numeracy skills (Bethell, 2016; Ndijuye, 2020). However, the data shows that Tanzania faces huge challenges in attracting sufficient numbers of suitably qualified applicants to train as mathematics teachers (MoEST, 2020). Even those attracted to teaching as a career all too often are said to receive inadequate training and, consequently, enter the profession ill-equipped to meet the considerable demands of the service (Mazana et al., 2020; Ndijuye & Rao, 2019; Rawle, 2015). Poor working conditions (Mazana et al., 2020), low pay and inadequate in-service support potentially result in low levels of motivation and low retention rates among mathematics teachers (MoEST, 2020). For instance, whereas in 2019 there were 6,812 trained pre-primary teachers in Tanzania, in 2020 the number had declined to 6,631 (MoEST, 2019, 2020). In rural regions and districts, the scarcity of high-quality early years mathematics teachers is acute. For instance, in the Kigoma and Katavi regions, which are the regions with the highest number of naturalised citizens, there were only 1,890 trained early numeracy teachers serving 212,888 early grades children (MoEST, 2020). The situation was much worse in schools in rural contexts serving naturalised citizens, where only 44 trained early numeracy teachers were serving a population of 5,289 children (MoEST, 2020).

While there are large numbers of unqualified or less qualified early grades mathematics teachers, the question that comes to mind is do they know enough mathematics to build a solid mathematical foundation for our children? The 2020 report by SACMEQ, of which Tanzania is a member, examined teachers' mathematical knowledge and skills by using a slightly extended variant of the multiple-choice test used for their students. The findings indicated that only 44 percent of the teachers passed the test at the B grade. In other words, more than half of the mathematics teachers were teaching mathematical content that they themselves could not understand. The root cause of the problem has been attributed to the quality of candidates for teaching posts, initial screening and selection, and the quality of pre-service teacher training programmes.

Furthermore, most teachers have consistently reported significant challenges when they try to teach mathematics in the classrooms of Tanzania. In general, the problems identified include poor physical facilities within schools, overly large classes and multi-grade teaching in the primary phase (Bethell, 2016; Ndijuye, 2020), as well as a shortage of textbooks and other teaching resources (Bethell, 2016; UNESCO, 2015). There is, however, considerable variation across the regions. In Katavi region, which has the highest number of naturalised citizens of Burundian origin, 9 out of 10 primary schools do not have electricity, and in Kigoma, the region with the second-highest naturalised citizen population, the child-to-textbook ratio for mathematics is 12:1 (MoEST, 2016). Such problems have implications for the quality of education provided and, inevitably, for children's early mathematics attainment.

The language of instruction policy in Tanzania is of particular importance as each of the 123 ethnic groups has its own vernacular language. After independence, Tanzania – then Tanganyika – radically adopted Kiswahili and English as official languages. In education, Kiswahili was adopted as the medium of instruction at primary school level, while English was kept for the lower secondary to tertiary levels

(URT, 2014). Among naturalised citizens, the language most commonly spoken at home is Kirundi (Kuch, 2017). Children from this group encounter Kiswahili at the classroom door.

Evidence has consistently indicated that children learn basic numeracy skills when taught in a language they understand (Nakiema, 2011; Qorro, 2013; UNESCO, 2015). Where teaching beyond the early years is conducted in an unfamiliar language, "both teachers and learners may often not be fluent enough to use the language as a medium of instruction" (Clegg & Afitska, 2010). This presents considerable challenges to teachers in all subjects, but the problem is exacerbated in mathematics, where both teaching and learning depend on teachers and students understanding the special "linguistic register" of mathematics (RTI International, 2014; Setati, 2002).

Conclusion and recommendations

This article ends with the conclusion that, while early numeracy skills establish the foundations for future mathematics learning attainment in particular and STEM in general, the situation in Tanzania is much in need of improvement. Critical improvements are required among learners who are naturalised citizens, where even mastery of Kiswahili – the medium of instruction – is challenging. Given the critical significance of early mathematics to the future learning attainment and life prospects of the children of immigrants and naturalised citizens in Tanzania, the study makes the following recommendations:

i. Broadening access to education does not guarantee that children are learning. There is a need to conduct regular tests to find out the extent to which the early grades children of marginalised naturalised citizens and other minorities are acquiring numeracy skills that reflect their grade levels.

ii. In the context of limited educational resources, the quality of early grades mathematics teachers is of vital importance for children's development of foundational numeracy skills. There is a need for Tanzania to invest in improving the quality of early grades mathematics teachers heavily and strategically, especially for children from the naturalised citizens group.

iii. The available empirical evidence documents that children acquire basic numeracy skills better in a language that is spoken at home. Most of the children of naturalised citizens speak Kirundi at home. As such, there is a need to revisit the current language of instruction policy in Tanzania.

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Math pedagogical practices in Kenya and Uganda, and their implications to learning in sub-Saharan Africa

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Abstract

This article focuses on the teaching styles and active teaching in East Africa in an attempt to examine what accounts for differences in performance between schools, and provide some lessons for sub-Saharan Africa. It uses data collected from 428 teachers in primary schools in Kenya; and 157 teachers in primary schools in Uganda. Assessment and classroom lesson video recordings of 436 lessons in math are used to generate evidence on patterns of teaching styles and active teaching. Results show that teaching practice in math is inclined towards the command and task styles that do not promote critical thinking among learners. The dominant teaching activity in math lessons was individual seat work in Kenya; and whole class chorus in Uganda. Overall, active teaching accounted for about half of the lesson time, with the other half being used in activities that do not directly enhance learning opportunities. After accounting for country-specific effects and the grade the teacher was teaching, teaching styles did not explain student performance in math, perhaps due to their ineffectiveness. The implications of these findings to the education systems in sub-Saharan Africa countries is the need to reinvigorate teaching practices; furthermore, any efforts to increase daily learning hours will be counterproductive as almost half of the lesson time is inefficiently utilized inside the classroom.

Introduction

Mathematics is a way of life, and it is no wonder that it is taught in all schools all over the world. In our everyday life, mathematics (math) relates to using numbers, measurement, and space to explain a phenomenon of interest. In using math, human beings engage in creative and critical thoughts, logic and looking for solutions.

Given the important role of math in our life, our education systems emphasize the need to build strong foundations in numeracy from early years of schooling and the effectiveness of teaching math. For effective teaching and learning of math[1], two mutually inclusive issues come into mind: (i) pedagogical strategies for teaching math; and (ii) how children learn math. These two are mutually inclusive because the latter is an outcome of the former. In this article, we focus on the former to examine how teachers deliver math instructions inside primary school classrooms in sub-Saharan Africa using data from Kenya and Uganda. The objective of this article is therefore to assess the pedagogical patterns of teaching math, and the extent to which such patterns could be explained by teacher attributes.

Systems of education and attainment levels

While the two countries have different systems of education, they largely mimic each other. Kenya is currently implementing two parallel systems of education, one under the 8-4-4, which was initiated in 1985 and is being phased out, and the competence-based curriculum (CBC) introduced in 2017 (MoE, 2018). The 8-4-4 emphasized progression from primary (8 years) to secondary (4 years) and university (minimum of 4 years) with summative exit examinations at the end of primary and secondary levels. The CBC system has two years of pre-school, six in primary school, and three each in junior and senior secondary schools (MoE, 2018). The structure of Uganda's basic education system which has been in place since independence includes seven years in primary, and four and two years in junior and senior secondary schools, respectively (Kan & Klasen, 2021). While pre-school is not compulsory in Uganda, like in Kenya under the CBC, it is highly encouraged.

The education attainment levels for the two countries differ significantly. For instance, based on SAQMEC IV results, significantly more grade six learners in Kenya (29.5%) had attained at least level 5 (competency) in numeracy compared to 11.2% in Uganda (SACMEQ, 2022). Similar patterns were also evident in literacy, with learners achieving at least interpretive reading (level 5) at 60.6% in Kenya and 31.7% in Uganda (SACMEQ, 2022). The 2021 Uwezo studies showed that only two in five children in Kenya could read grade 3 English text (Uwezo, 2021), while in Uganda only 33% of primary three to seven children could read a primary 2 English text (Uwezo, 2019).

The approach

We use primary data from two close sectional surveys conducted in 2012 and 2015 in Kenya and Uganda respectively. The surveys had teaching styles as part of their focus in an attempt to examine what accounts for differences in performance between schools. This article uses data, collected from 428 teachers in primary schools in urban informal settlements in Kenya, and 157 teachers in primary schools in rural Uganda. Additionally, assessment and classroom lesson video recordings of the 436 math teachers (not all teachers were video recorded), and interviews with subject teachers in the primary schools in the two countries are used to generate evidence on patterns of teaching styles.

The rest of this article is organized as follows: The next section focuses on empirical evidence on math pedagogical practices in Kenya and Uganda. This is followed by a section on discussion that puts the evidence in the context of literature on teaching math, and the strands of math proficiency. In the last section, we provide our own insights and recommendations for policy and practice in the context of education systems in SSA.

Evidence on math pedagogical practices in Kenya and Uganda

In this section, we provide results on math teacher characteristics in Kenya and Uganda, teachers' mastery of math teaching knowledge, the associations between the teaching knowledge and teacher attributes based on multivariate regression, observed math teaching styles in primary school grades 3 and 6, and finally we attempt to map teaching knowledge on math teaching styles.

Math teacher characteristics

Table 1 shows selected characteristics of the math teachers. Overall, 44.4% and 59.2% of the math teachers in Kenya and Uganda were male. When this is stratified by grade, in Kenya, 30% of the grade 6 math teachers were female while in grade three, 81% were female. We observe a similar pattern in Uganda, with 84% and 16% of grade 3 and 6 math teachers being female. In Kenya and Uganda, early primary school grades (e.g. grade 3) are usually allocated to one teacher who teaches all the subjects to students in the allocated class. These statistics imply that in Kenya and Uganda, and perhaps in SSA, early grades are usually allocated to female teachers. In Kenya, while 91.4% of the math teachers had secondary education as their highest academic level, 27% of them had no pre-service teacher training (teacher preparation). On average, teachers in Kenya had about 10 years of experience in teaching mathematics, while in Uganda, on average, had about 9 years. This is an indication of a young teaching force or delayed recruitment into primary school teaching after completion of training or studies.

1 In this article, we use the term math and numeracy interchangeably. However, it should be noted that numeracy has more to do with application of math in real life, and understanding the potential application of math.

Table 1: Math teachers' selected characteristics.

Variable		Kenya	Uganda
		N=428	N=157
Sex	% Female	55.61	40.76
Grade	% Grade 6	50	50.96
Highest academic education	Primary Education	1.17	15.29
	Junior Secondary	0.47	0
	Secondary Education	91.35	84.08
	At least a degree	7.01	0.64
Professional training	Untrained	27.34	5.1
	Certificate	56.31	68.79
	Diploma	10.28	24.84
	Degree	5.61	1.27
	Others	0.46	0
Years as math teacher	Mean (Std. Dev)	7.96 (8.50)	5.16 (5.59)
Average age (years)	Mean (Std. Dev)	32.34 (10.86)	32.51 (8.51)
Average Class Size taught	Grade 3	35.73 (22.67)	61.82 (32.73)
	Grade 6	34.03 (22.87)	55.9 (30.41)
Average years of teaching	Mean (Std. Dev)	9.63 (9.37)	8.81 (6.38)
Average workload (lessons/week)	Mean (Std. Dev)	30.51 (8.41)	23.79 (15.94)

Notes: Junior Secondary is two years of secondary education; while secondary Education is either four or six years; Untrained means no pre-service training.

Teaching knowledge

Among the attributes that define quality teaching is how well teachers exhibit content knowledge (CK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK) inside the classroom (Carnoy et al., 2008; Georges et al., 2010; Sorto et al., 2009). In this section, we present the results of CK, PK and PCK (in this article, we refer to the three as teaching knowledge) of the math teachers derived from a math knowledge assessment tool (accessible from APHRC on request) administered to grades 3 and 6 teachers in Kenya and Uganda (Ngware et al., 2013; Ngware et al., 2016). We show the performance of teachers in both countries on items meant to measure the three key domains of teaching knowledge considered as essential to effective instruction delivery (Hwang et al., 2018; Shulman, 1986). The three domains are conceptually related though not entirely correlated, with CK encompassing the knowledge of the teacher in the subject matter, PK on how the teacher delivers teaching and strategies used, while PCK referring to the dynamism that guides the teacher to make decisions on delivering learning in diverse classroom situations – i.e. contextualized settings (Loughran et al., 2012; Shulman, 1986).

There is a low correlation between the knowledge domains. That is a correlation of 0.34 between CK and PK, 0.41 between PK and PCK, and 0.44 between CK and PCK. The scores presented in Table 2 can be interpreted out of a possible 100%. Overall, we see a low performance in these key teaching knowledge domains for both countries and grades. In Uganda, while teachers knew the content (high score in CK), delivery and contextualizing it in the classroom seemed to be a problem (low score in PK and/or PCK), while in Kenya, performance in CK, PK and PCK seem not to differ much. The grade 6 math teachers, and male teachers had better performance across the knowledge domains in both countries.

Table 2: Teacher performance (mean scores) on teaching knowledge domains.

		Overall	Grade 3	Grade 6	Female	Male
Kenya	CK	52.14 (1.16)	44.93 (1.68)	59.18 (1.46)	49.29 (1.55)	55.6 (1.72)
	PK	45.29 (0.97)	42.4 (1.35)	48.11 (1.36)	45.22 (1.29)	45.39 (1.46)
	PCK	52.11 (0.83)	46.79 (1.18)	57.31 (1.07)	50.07 (1.14)	54.6 (1.2)
Uganda	CK	51.01 (1.6)	45.13 (2.29)	56.58 (2.07)	44.68 (2.62)	55.27 (1.91)
	PK	29.37 (1.16)	28.15 (1.55)	30.52 (1.7)	28.49 (1.8)	29.95 (1.51)
	PCK	36.62 (1.3)	33.47 (1.88)	39.62 (1.73)	35 (2.02)	37.72 (1.69)

Notes: The test items had multiple responses and teachers were asked to choose/select the best option. For instance, a task would present a procedure for getting the product of 740 and 7. The teacher would be required to select the best option that explains what is happening in the presented procedure. The teacher performance is computed out 100%.

Association between selected teacher characteristics and teaching knowledge

We further explored teacher characteristics associated with the domains by running a multivariate regression. The multivariate regression helps understand the relationship between the three teacher knowledge measures and key variables that can influence the outcome measures. While knowing how well teachers understand the teaching knowledge is important in targeting teacher professional development (TPD) and allocation of teaching tasks, it is equally important to examine patterns and associations between the teaching knowledge and teacher attributes. This will add value to decision-making on teacher in-service training interventions that take context into consideration. To examine such patterns, we use a multivariate regression model. The variables included in the model were teacher gender, academic education level, professional training, grade taught, years as a mathematics teacher, and a score on self-reporting on whether the teacher felt adequately prepared to teach math (Table 3). The coefficient can be interpreted as how much the teacher knowledge measure change for a unit increase in independent variables or characteristic. For instance, how male teachers perform in relation to female teachers. Positive coefficients indicate an increase in performance for a unit increase in the characteristic of interest while negative indicates decreased performance.

In all the knowledge domains, teacher performance was significantly associated with the grade. That is, grade 6 mathematics teachers performed better in the three knowledge measures as compared to those teaching grade 3. The associations among teacher levels of academic education, professional training, and CK are intriguing. Teachers with better education (e.g. completed secondary) and those trained had lower scores in CK and PK than those with primary education or not trained. However, for PCK, trained teachers scored significantly more than those with no teacher professional training - implying that pre-service teacher training adds value. Further, teachers who felt they were adequately prepared (self-reporting or proxy

for confidence) scored significantly higher in both CK and PCK. Also intriguing is the revelation that experienced teachers seemed to demonstrate lower teaching knowledge compared to those with fewer years of teaching - though only significant for PCK.

Table 3: Multivariate regression results.

	Outcome variable					
	CK		PK		PCK	
	Coef		Coef		Coef	
Gender						
Male (*Ref: Female*)	0.18		-2.45		-0.86	
Grade						
6 (Ref: grade 3)	13.08	**	5.68	***	9.01	**
Education						
Secondary (Ref: below secondary)	-8.34	*	2.10		-0.40	
Degree (Ref: below secondary)	-5.12		7.29		3.96	
Professional training						
Certificate (Ref: Untrained)	-0.75		1.76		6.45	**
Diploma/degree (Ref: Untrained)	-2.85		0.36		4.69	**
Country						
Uganda (Ref: Kenya)	-0.54		-14.34	**	-16.16	**
Adequately prepared (Yes)	8.26	*	5.16		5.95	*
Years as subject teacher	-0.06		-0.01		-0.25	**
Constant	46.89		35.25		40.05	

Notes: P-values ** P<0.001; * P<0.05. Scores for CK, PK and PCK are treated as the outcome variable; Coef=Coefficient

Teaching styles inside the classroom

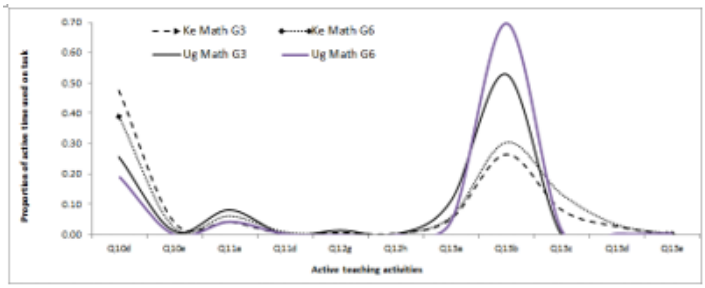
This study analyzed recorded videos and mapped the various teaching activities using a predefined rubric that sought to distinguish between active activities (evidenced student-teacher interactions or student involvement), and inactive activities (little or no interactions or no student involvement). To capture the interactions and/or involvements, the activities were grouped into four main observable categories of individual seat work, whole-class teaching, recitation and group work. More than half of the lesson time was spent on whole-class teaching (teacher speaking and pupil listening), and individual seatwork. The math teachers engaged less in individual and group work. The activities were further grouped into three zones as shown in Figure 1: Zone A as inactive activities that do not directly enhance learning; Zone B and C as activities that promote active teaching but at various levels. The main difference between Zones B and C emanates from student involvement – in Zone B the student asks the questions, while in Zone C the teacher asks the questions. In the two countries, other than in grade 3 in Kenya, about half of the math lessons utilized activities that do not directly enhance learning such as transitioning to an activity.

From Figure 2, whole class activities seem to drive the active teaching zones, with most of the time spent on whole class demonstration (q13b), and whole class instructions (q13a) by the teacher. In addition, a considerable proportion of the time is spent on teachers checking individual work, with

	Zone A	Zone B	Zone C
	Inactive teaching time	Active teaching time	
	Proportion (%) of lesson time		
Ug, math G3	49.37	13.27	37.36
Ug, math G6	47.59	15.12	37.29
Ke, math G3	40.75	6.04	53.21
Ke, math G6	51.52	3.55	44.93
Activities	Activities that do not directly enhance learning opportunities, Eg. Transitioning	Activities: Teacher checking work Individual (stopped); Question and answer – with the student asking; group work with the teacher support; and whole-class teaching, review and lesson evaluation	Activities: Teacher checking individual work; Question and answer with the teacher asking questions; whole class task instruction and demonstration.

Notes: G3/G6=Grades 3/6; Ug=Uganda; Ke=Kenya; We used a timeline analysis rubric to examine recorded videos (classroom observations). This enabled us to capture activities performed by learners and the teacher in the classroom at regular intervals – including teacher-pupil classroom interaction as well as opportunity to learn.

Figure 1: Time spent on active teaching.



*Description of terms/activities used in Figure 2

Q10d	Teacher checking work Individual (working)
Q10e	Teacher checking work Individual (stopped)
Q11a	Q A: Individual learner (Teacher asks)
Q11d	Q A: Individual learner (Learner asks)
Q12g	Teacher checking work group (working)
Q12h	Teacher checking work group (stopped)
Q13a	Whole class task instructions (Teacher only)
Q13b	Whole class demonstrations (Teacher only)
Q13c	Whole class lecture (Teacher only)
Q13d	Whole class review/recap (Teacher only)
Q13e	Whole class evaluate lesson (Teacher only)

Figure 2: Proportion of active teaching time used in each of the active teaching activities.

learners working individually (q10d) and learners asking questions (q11a). We also observe country differences, with teachers in Uganda spending over half of the active teaching time on whole class instruction and demonstration as compared to about 30% in Kenya.

Mapping teaching knowledge to teaching styles

We further related teacher math knowledge with the teaching zones. This was to understand whether teacher knowledge could influence active teaching. To do this, we identified classrooms whose teachers spend at least 50% of the lesson time in a particular zone. The results presented in Table 4 do not show a clear pattern of an association between

time spent on active teaching and teacher knowledge. While in Kenya, grade 6, there is a pattern that is emerging when comparing scores in Zone A (inactive teaching) with Zone BC (active teaching), the differences are not large and conclusive. We are therefore persuaded to believe that there may be little or no association between math teaching knowledge and math teaching styles among math teachers in Kenya and Uganda.

Table 4: Relating active teaching time to teacher scores.

			Teacher mean scores		
Zone	Grade	# of Teachers	CK	PK	PCK
Zone A	UG3	16	47.5	27.8	37.8
	UG6	16	56.9	27.1	39.4
	KE3	38	47.8	42.1	48.4
	KE6	40	54.5	47.8	53.3
Zones B & C	UG3	14	41.4	30.2	37.9
	UG6	24	56.5	33.3	36.9
	KE3	105	41.6	40.1	46.3
	KE6	92	61.6	50.1	60.1

These results highlight the approaches that teachers in Kenya and Uganda employ while teaching math. They also highlight lost opportunities to learn math by learners occasioned by both limited knowledge of the subject and engagement in teaching activities that do not promote learning. These are interrelated, and possibly, the poor use of time in the classroom could be attributed to teachers' teaching knowledge (CK, PK, PCK), which was low.

Discussion

Teacher characteristics: Results from the teacher characteristics show that in East Africa, and perhaps elsewhere in SSA, female teachers dominate lower primary grades. We further see that in Kenya, teachers have slightly longer years of experience (10) compared to teachers in Uganda (9). This implies that we expect some countries in SSA to have teachers who have been in the same position for long (though recent statistics are hard to come by), and perhaps Kenya and Uganda typify such countries, while others may have a less experienced workforce. The retirement age in many African countries for public servants, including teachers, is between 55 and 60 years, and with an average age of about 33 years in Kenya and Uganda, the teaching force can be described as young. Interestingly, data from the Kenya study showed a negative correlation between student math scores and years of teaching experience among teachers in public schools (see Ngware et al., 2013). According to Ngware et al. (2013), for teachers in private schools, as years of teaching experience increased, students' scores in math increased and reached a maximum of about five to six years of teaching experience – there after the students' scores declined. The 2013 study seems to suggest that in private schools, teachers' productivity begins to decline after five or six years in a school. This implies the need for continued professional development to keep productivity high as well as continuous improvement of the teaching environment. Unfortunately, the study did not find a similar pattern in public schools. Of course, we did find that a considerable proportion (e.g. 27% in Kenya) of teachers did not have pre-service training, and this may have contributed to low performance among their students.

Teaching knowledge: In Africa, the majority of primary school teachers are secondary school leavers and/or graduates. In our study, over 84% of teachers in Kenya and Uganda have had secondary education. Additionally, a considerable proportion (over 70%) of teachers have pre-service training. It should therefore be of concern when these math teachers fail to demonstrate mastery of teaching knowledge (they demonstrated low scores in teaching knowledge, that is 39% and 50% in Uganda and Kenya, respectively). Low mastery of teaching knowledge implies suboptimal delivery of contents that could ultimately jeopardize students' progress in math (Mammadova, 2019; Singh et al., 2019; Snoek, 2021). That said, there are variations in teaching knowledge across countries though this (variation) is not translated or associated with student performance. For instance, in Uganda, while teachers had better mastery of the content knowledge, this did not translate to higher scores among their students. The results of the teacher teaching knowledge assessment also confirms that teachers with low 'quality of qualifications' are allocated to the lower grades – for instance, in the two study countries, grade 6 teachers performed better (42% and 55%) than grade 3 teachers (36% and 45%). Interestingly, grade 3 teachers in Kenya outperformed grade 6 teachers in Uganda – an indication of huge variations in teacher quality in SSA. The variations in the demonstration of teaching knowledge implies gaps in quality of instructional delivery that could be a source of inequality in learning opportunities among students. Similar findings have been reported by UNESCO and other researchers in various countries in SSA (Nordstrum, 2015; UNESCO, 2021). Our results also show that female teachers scored less than male teachers did. While there is no evidence to believe that performance is driven by the teachers' gender, it is notable that the majority of teachers in grade 3 are females, and if their performance is low (as shown in this study), this again exposes many grade three learners to less learning opportunities. The presence of more female teachers in lower primary school grades could be explained by two related factors. First is the stereotype that women are good at playing the role of the mother, and especially providing emotional support to young children. Second, it may be the case that female teachers, who also double as mothers, prefer allocations in lower primary, especially grades 1-3, that have fewer demands on their time, hence this provides flexibility to attend to household chores. In some schools, grades 1-3 attend lessons for half a day.

Association between teacher attributes and teaching knowledge: Understanding the association between teacher attributes and teaching knowledge is one way to explore what drives teaching knowledge. In our study, there is evidence to suggest bias in teaching allocations with 'weaker' (in terms of teaching knowledge) teachers allocated to lower grades – these teachers scored significantly lower

than grade 6 teachers. Again, this does not augur well for systems that would likely build strong foundation years at this time of global learning crisis (World Bank, 2019). 'Better' teachers (e.g. with secondary 4 and/or 6 qualifications, or higher teaching knowledge scores), and those with pre-service training demonstrated better mastery of teaching knowledge. By extension, this implies a need for the recruitment of teachers with higher academic and training qualifications. Of course, it was interesting to find that experienced teachers could not demonstrate better teaching knowledge than those who were less experienced – perhaps a demonstration of laxity and/or comfort zone as they get accustomed to their environment. It may also be the case that their entry knowledge was low, and years of teaching experience have not helped to improve it.

Teaching styles: Instructional strategies are critical in improving learning outcomes (Kim, 2015; Rice, 2003; Snoek, 2021). Though it is popular to use and advocate for student-centered pedagogy as it is known to enhance learning (Dong et al., 2019), students at different skill levels in math seem to benefit from different pedagogical styles – this is because they process information differently (Hawk & Shah, 2007). However, our findings show the amount of Zone A activity is very high, and effective teachers may be able to use various teaching styles to cater for the diverse learning needs of their learners. Additionally, the teaching styles are a function of teacher attributes, including the math teaching knowledge. Our study did not find any strong association between teaching knowledge and teaching styles – implying that the deployed teaching strategies are chosen either randomly or conveniently as opposed to being chosen systematically and based on an understanding of the effectiveness of the style. In fact, in Kenya and Uganda, we find no or little association between teaching knowledge and teaching styles among math teachers.

Our analysis made deep dives into the teaching style to unpack those that were active from those that could be described as inactive/passive (see Figures 1 and 2). These activities were grouped under four broad and common (in classrooms) math teaching styles - individual seat work, whole-class teaching, recitation and group work. What we find common among math teachers is the use of whole-class teaching that involved the teacher speaking/telling while students were passive listeners, individual seat work and/or marking/ticking learners' books. These three common teaching activities are not student-centered and hence do not meet the expectations and/or may not be effective in enhancing student performance (Dong et al., 2019; Keiler, 2018). These kinds of styles hardly produce a math-proficiency learner and, in any case, largely disadvantage learners that need either one-on-one, scaffolding, or individualized attention. In fact, 50% of the lesson time was spent on activities that did not directly influence learning (transitioning), such as picking books, wiping the chalkboard, and walking from one point of the classroom to another, among others. While these activities or actions may be necessary, the time spent on them is obviously on the higher side and, by implication, reduces learning opportunities and exposure.

Conclusions and recommendations

In this article, we have shown that female teachers dominate lower primary school grades, and score relatively lower than male teachers in math teaching knowledge assessment. However, this should not be construed to imply that female teachers are not good at math. It may be the case of selection bias – that female teachers who join the teaching profession have low learning outcome scores because of specific affirmative actions adopted by governments. We also find that teachers with more years of experience are not always the best in raising learning outcomes in math.

The current crop of primary school teachers in Kenya and Uganda, and perhaps in many other countries in Africa, struggle with math teaching knowledge. If teachers cannot get it right, then it would be difficult to impart the same and/or facilitate the same to be acquired by their learners. This, if left unaddressed, will continue to create gaps in learning opportunities inside the classroom.

In SSA countries such as Kenya and Uganda, there seems to be an unwritten rule whereby 'weak' (low academic and/or professional qualifications) teachers are assigned to teach in lower primary school grades. If this trend continues, it will exacerbate the learning crisis. There also seems to be an assumption that early grade learners have many opportunities to recover from any learning gaps experienced in their early years. To worsen the situation is the common teaching approaches during math lessons – mainly didactic and hence may not produce an independent learner or a learner who is proficient in math. Perhaps it is these kinds of approaches that make it convenient for math teachers to spend a lot of time in activities that do not directly enhance learning among the students.

Recommendations for sub-Saharan African countries

- There is a need for continued professional development to keep productivity high. While this is happening in some countries, it would be important to make it more targeted in terms of grades the teachers teach, teaching subject areas, math contents, among other teacher attributes that could be related to productivity.

- Foundational years, e.g., early primary school grades, are critical in laying a strong foundation for future success in school. It is therefore imperative that SSA education systems make it a practice to allocate their best teachers to lower grades. This may also contribute to addressing the global learning crisis.

- Additionally, minimum entry qualifications to teacher training and/or teaching should be reviewed upwards. Better-qualified teachers are more likely to grasp the pedagogical concepts, including the knowledge of the teaching subject.

- To change the current and didactic teaching styles inside classrooms, education systems should support teachers inside the classroom with 'how to' teach more effectively. This could be done through school-based coaching activities, among other strategies.

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Determinants of Mathematical Educational Achievement in Cameroon

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Abstract

This article presents a quantitative analysis of the determinants of student scores on a standardized mathematics assessment in Cameroon, a sub-Saharan African country with Francophone and Anglophone school systems. Using the mathematics component of the 2014 Programme d'Analyse des Systèmes Educatifs de la CONFEMEN survey, we examined the importance of community, school and classroom resourcing, teacher attributes, student characteristics, and family circumstances. Our results generally suggest that both school and family factors play a role in determining student achievement in mathematics. We found that student mathematics scores are highest for males, younger students, non-grade repeaters, urban students, when teachers are better resourced, and when students come from well-off family situations with parents who are able to read. Analyses of sub-samples and an expanded sample (with interaction effects) generally corroborate these results but also reveal further differences, including between the Francophone and Anglophone school systems. Finally, the results indicate that the kindergarten program is not systematically associated with better mathematics test scores, suggesting that this policy may need further study and modification.

Introduction

Promoting inclusive and sustainable economic growth in Africa through human capital development that is underpinned by science, technology, and innovation is the first aspiration of the African Union's Agenda 2063. However, there is a growing recognition that countries in sub-Saharan Africa (SSA) are falling behind in Science, Technology, Engineering and Mathematics (STEM) education compared to the rest of the world. World Bank and Elsevier (2014) suggest that the relatively lower research output in SSA could be explained by a number of factors: "the low quality of basic education in science and math within SSA; a higher education system skewed towards disciplines other than STEM such as the humanities and social sciences" (p. 4).

Concerns around the quality of science and math education, however, likely apply to the general quality of schooling. As such, improving basic math and science outcomes in SSA will have a spillover effect on the overall educational quality of primary education and other levels of education.

This article extends Medu (2019), who investigated student-level performance on regional assessments of mathematics and language skills in Cameroon. We used more recent mathematics test scores to examine the role of five groups of explanatory variables on student performance: community conditions, school and classroom resources, teacher characteristics, student attributes, and family environment. We chose Cameroon for the case study mainly because of its dual-language schooling systems, which offer additional sources of variation within a single country context; French and English are also individually the languages of instruction in much of SSA. We focused on a single country case study since we are interested in identifying lessons relevant for policymakers, who operate within national educational systems. Though we focused on the Cameroon experience, some of these policy lessons may apply more broadly.

Country context

Cameroon is a lower-middle-income country in SSA with a current population (2021) of approximately 27 million. The population is growing at around 3%, and school-age children (ages 5-19) comprise 37% of the population, both well above the global averages of 1% and 25%. The majority of the population (58%) is located in urban areas (World Bank, 2022).

Portuguese explorers were the first modern Europeans to establish contact in the area, which became a focus of slave trading and missionary activity. The region was formally established as a German colony in 1884 but was divided into separate British and French colonies during the First World War. The larger, more populous, and more economically developed French Cameroun became independent in 1960, but a plebiscite the following year saw it joined by the Southern portion of British Cameroon to form a united, bilingual republic (Awasom, 2000). The initial federal structure was replaced by a unitary system in 1972, which has led to some discontent and calls for secession by some of the Anglophone population.

Roughly 80% of the population live in the eight Francophone regions, with the remainder in the two Anglophone regions (see Figure 1). The simple division based on official European languages obscures the linguistic reality of over 200 local languages and considerable ethnic and cultural diversity. It is a common feature in SSA for students to be educated in the language of their prior colonial ruler, which is often a student's second or third language. The two language-based school systems have maintained the traditions of their colonial administration, with the Francophone system being highly centralized relative to the Anglophone administrative structure. While several key differences between the two systems still exist today, both provide free primary education (see Fallwickl et al. (2021) and Medu (2019) for more information about the education sector administration).

Figure 1: Map of Cameroon showing the linguistic region. Source: https://wenr.wes.org/2021/04/education-in cameroon

During the 1970s and 1980s, Cameroon had one of the most effective education systems in Africa (World Bank, 2012). For example, in the early 1980s, the basic school enrolment rate in Cameroon was one of the highest in SSA. Primary education access and enrolment continue to be high in Cameroon, however, there are marked differences in educational outcomes across gender and geographic locations. In 2014 when the PASEC survey was conducted, PASEC (2016) noted that the primary completion rate in Cameroon was 74% on average (70% for girls and 78% for boys). Similarly, the completion rate for Priority Education Zones (Adamawa, East, Far North and North) was only about 64%.

In 2009, the government adopted Cameroon Vision 2035, a development framework geared towards making Cameroon "an emerging country, democratic and united in its diversity by 2035". Education is considered a crucial factor in achieving Cameroon Vision 2035 as outlined in the National Development Strategy 2020-2030 (Republic of Cameroon, 2020). In the education and training sector, the Government's vision is to promote an educational system where every young graduate is sociologically integrated, bilingual and competent in an area that is fundamental to the country's development.

The World Bank (2018) noted that Cameroon's education sector continues to face a number of structural issues, including regional and gender differences in access to basic

education; poor quality of basic education (resulting in part from shortage and poor distribution of teachers around the country); limited provision of early childhood development programs; weak sector management and governance (including inadequate sector coordination and planning); and poor sector financing, and internal inefficiency.

The Anglophone crisis, which arguably dates back to colonial times and can largely be attributed to the marginalization of the Anglophone minority, erupted in earnest in 2017 (after our sample period), and is now worsening the disparities and inequalities within the education system. In 2019, UNICEF reported that more than 855,000 children in the two Anglophone regions were out of school, some for about three years. The intensifying Boko Haram crisis, which began having more serious effects in the Far North of Cameroon in 2012, also continues to impact the education system, particularly those living in border areas close to Nigeria and Chad.

The insurgency intensified in 2014, the year of the PASEC survey in this study (Afu, 2019). This disruption may have affected our results, though it is unlikely that children caught in the violence would have been included in the survey. It does appear that students in the Far North and North regions of Cameroon do perform worse on test scores, though poorer outcomes may reflect the many disadvantages related to the relative remoteness of the area. Future surveys may help shed more light on the effects of the insurgency on scholastic achievement.

Cameroon has undergone a number of recent reforms (some involving international partnerships) focused on the education sector. For example, the Ministry of Basic Education (MINEDUB) undertook a massive reform of the nursery and primary school curricula that was implemented in the 2018/19 school year. Also, the World Bank Education Reform Support Project, geared towards promoting equitable access to quality basic education, was implemented in Cameroon in 2018 and is slated to be completed in 2026. While robust evaluations are currently not available, the expectation is that these reforms and others underway within the country will lead to tangible and sustainable improvements within the education sector as well as the broader economy in the near future.

Literature review

In general, two streams of determinant factors of educational achievement are reported in the literature: family factors and school factors. This strand of literature is rooted in a landmark study from the United States (Coleman et al., 1966), which suggested that family differences are very important in explaining variations in achievement across students. This assertion was disputed for developing countries by Heyneman and Loxley (1983). They argued that school effects were more important for student achievement in developing countries, referred to as the 'Heyneman-Loxely effect, Heyneman/Loxely effect, H/L effect or HL effect' (for example, Badr et al., 2012; Baker et al., 2002; Heyneman, 2015).

A number of studies have re-examined the Heyneman-Loxley effect over time and highlight the possibility of changes in the effect over time. For example, Baker et al. (2002) reported a vanishing HL effect cross-nationally and proposed a number of explanations for the diminishing effect, including the level of school development as well as the availability and quality of school resources. In general, they noted their results "demonstrate how institutions of family and school interact over time because of changing macrosocial conditions… a third powerful institution, the nation-state,… changes the conditions under which the family and the school articulate achievement and status reproduction" (p. 310). Also, Zumbach (2010) suggested that the effect did not apply unconditionally, though it is more pronounced for SSA countries with higher levels of development.

The literature on determinants of educational quality is quite rich and has been subject to numerous reviews over the years (for example, Gleewe et al., 2011; Hanushek, 2003, 1997; Simons & Leigh, 1975). Fehrler et al. (2009, p. 4) provided a useful summary of the general literature:

> We conclude that despite rather discouraging evidence on the international level, for developing countries in general, and for most of the very poor sub-Saharan African countries in particular, school resources still play an important role in improving education quality. However, even for these countries, the estimated relationship between school resources and student achievement is far from consistent across studies, so that there is no easy recipe for successful policy interventions.

Recent reviews of the African literature highlight the importance of school-based factors and teacher ability. For example, some prioritize teacher training to improve pedagogy, instructional techniques, and assessment strategies (Conn, 2017; Bethell, 2016). Evans and Acosta (2021) highlighted the importance of multi-pronged responses to promote educational access and quality, particularly structured pedagogical and teacher interventions, including teacher training, teacher coaching, semi-scripted lessons, learning materials and mother-tongue instruction. Focusing on mathematics specifically, Ngware et al. (2015) used Kenyan data to argue that the most critical factor in improving student abilities, especially for low-performing students, is the quality of instruction.

Other studies emphasize the pivotal role of family and cultural factors (Bethell, 2016). Jurdak (2014) examined 18 countries that participated in the 2003 Trends in International Mathematics and Science Study, including three SSA countries. The results showed that the differences in mathematics achievement and between-school equity in mathematics education can largely be accounted for by socioeconomic and cultural factors (such as ethnicity, language and religious differences).

Gruitjers and Behrman (2020) studied the relationship between family socioeconomic status and learning outcomes in 10 SSA countries using 2014 data from the Programme

d'Analyse des Systèmes Educatifs de la CONFEMEN (PASEC). Their main measure of learning outcomes was mathematics test scores. While results generally support the importance of school quality as a determinant of learning outcomes in low-income contexts (the 'Heyneman-Loxely effect'), they qualify their conclusion by highlighting the importance of family background in determining the school a child attends. As such, "Ignoring the association between family background and school quality omits an essential pathway through which socioeconomic (dis)advantage affects children's learning outcomes" (p. 272).

Finally, Allier-Gagneur and Gruijters (2021) re-assessed the Heyneman-Loxley hypothesis using the full 2014 PASEC dataset on all ten countries in the PASEC survey. Their main measure of learning outcome was mathematics test scores and they conducted a general dominance analysis. Their results did not support the existence of the HL effect and generally suggested that "both schools and families have a substantial impact on learning outcomes in low-income contexts… to reduce learning inequalities, it is not sufficient to provide schools with more and better resources. Policy makes also need to pay attention to students' experiences outside of and before school" (p. 13). It is good to note that our analysis differs from their study in terms of estimating technique, as well as in our focus on one country to examine specific conditions and policy instruments in more detail.

In general, the empirical findings on mathematics teaching in SSA remain inconclusive. The specific strengths and weaknesses of an education system are best identified separately for each country, even though the associated lessons may not apply specifically to other countries. We focus on Cameroon to identify specific targets for policy attention.

Empirical analysis

Conceptual framework, sample and variables

The economics of education is mainly based on a human capital production function. The model asserts that the educational achievement of a student is partly related to policy inputs that are to some extent directly controlled within the education system (including administrative structure, curricula, school resources, classroom characteristics, and teacher quality), and factors largely exogenous to the system (innate student ability, parent attributes, and family resources). While educational achievement is typically measured at specific time periods, knowledge acquisition is cumulative and past inputs do influence current levels of student achievement (Hanushek, 2007).

We used the 2014 PASEC mathematics assessment results for 3,817 Francophone and Anglophone grade six students in Cameroon as the dependent variable representing student achievement. In conjunction with testing in mathematics and language, questionnaires were also administered to students, teachers and principals to gather information on the general conditions of schooling and the background of students and teachers.

The 2014 PASEC student level assessment data Cameroon was provided by Conférence des Ministres de l'Éducation des États et gouvernements de la Francophonie (CONFEMEN) through a special request. PASEC's standardized assessments are conducted in 22 Francophone SSA countries by CONFEMEN. The 2014 assessments followed a significant methodological revision and was conducted in ten Francophone SSA countries (Benin, Burkina Faso, Burundi, Cameroon, Chad, Congo, Côte d'Ivoire, Niger, Senegal and Togo). The survey sample is representative of the various geographic regions covered by both sub-systems, including the far North despite the relatively high level of instability in the region during the survey period. PASEC (2016) notes that the school participation rate in the grade six assessment in both sub-systems was higher than the 80 percent minimum threshold for publishing and international comparison. Student participation in both systems was also closer to 90 percent. Also, PASEC (2017) notes that Cameroon is one of the countries that over-sampled segments of their population for the purpose of additional analysis.

The analysis does have some limitations. Using a single survey means that we are taking a snapshot from one year and cannot address intertemporal variation in student performance or circumstances. Second, our focus on numeracy ignores other important dimensions of cognitive competence, many of which do not easily lend themselves to standardized tests, though it can be argued that cognitive skills in mathematics and science may serve as a proxy for other skills (Wößmann, 2003). Finally, our analysis uses assessments from grade six students, so its findings apply directly only to primary education. Primary education is foundational and has important subsequent effects on knowledge and skills acquisition at higher levels of education. There is also a strong correlation between grade six completion and family socioeconomic status (Gruitjers & Behrman, 2020). Also Hanushek and Woessman (2011) provide a high-level summary of the key issues related to empirical identification of education production functions.

The performance of the pupils on the PASEC tests was estimated using plausible values. For each student, five plausible values are assigned, which were transformed so that the average was equal to 500 and the standard deviation to 100. According to Wu and Adams (2002):

> "The simplest way to describe plausible values is to say that plausible values are a representation of the range of abilities that a student might reasonably have... Instead of directly estimating a student's ability, a probability distribution for a student's ability is estimated… Plausible values are random draws from this (estimated) distribution for a student's ability" (cited in OECD, 2009, p. 43).

The estimation procedure regresses each plausible value (PV) against five groups of explanatory variables representing the characteristics of the community, classroom, teacher, student and family. Each group is represented by several variables, which are identified in equation 1 in Appendix 1; details of these variables are also provided in Appendix 1.

Several additional independent variables were also considered, including: teacher's absence, teacher's monthly salary, school budget per student and language spoken at home. However, these variables were excluded for a number of reasons, including coding issues, missing observations, and minimal variation in the sample. Preliminary tests indicated that their exclusion did not affect these results.

Estimation approach and results

The equation was estimated using Ordinary Least Squares Regression analysis was conducted using the STATA "pv" module designed to perform plausible value estimations. The module was created specifically (but not exclusively) for use with international achievement datasets such as the Organization for Economic Cooperation and Development (OECD)'s Programme for International Student Assessment and Programme for the International Assessment of Adult Competencies (for more information, see MacDonald, 2019).

Diagnostic tests did not reject the null hypothesis of normally distributed residuals (Shapiro-Francia test) and did not detect any significant problems of multicollinearity (all Variance Inflation Factors are under five). A Breusch-Pagan test for heteroscedasticity was inconclusive, but a comparison of the unweighted and weighted OLS results suggested that homoscedasticity was a reasonable assumption, so we reported only the unadjusted results.

The primary estimation used test scores for all students, with the explanatory variables organized according to community and classroom conditions, teacher attributes, student characteristics, and family situation. Table 1 presents the results for both the full estimating equation and a step-wise reduced version. The reduced model allows for a larger sample and a focus on the most interesting and robust results. Alternative specifications of the full model were also estimated based on sub-samples and interactions related to educational system, school location, student gender and kindergarten attendance. The coefficient estimates and their levels of statistical significance were generally consistent across the different estimations. Accordingly, the discussions are based on the reduced model results and significant effects from the alternate models. The discussion of the results is grouped based on the identified five groups of explanatory variables: community, classroom, teacher, student and family-related factors beginning with the reduced model findings.

Community-related variables

Community-level variables identify linguistic variation (Anglophone regions and Francophone regions), rural-urban distinctions, and a community development index. Only the rural-urban distinction affected math scores, with urban students averaging 71 points higher (representing about 15% of the sample average math score, and over 75% of a standard deviation). While location is not a policy variable, this result suggests that education authorities may want to investigate further the possible sources of rural-urban performance differentials (urban students are approximately 36% of the sample).

It is good to note that the rural-urban distribution of school in the PASEC sample shows that less than 40 percent of schools were located in urban areas. PASEC (2016) confirmed this distribution and noted that Cameroon was one of the three countries where the majority of pupils in the sample were educated in rural areas. It is also important to note the difficulty associated with comparing between the high-level PASEC definition of rural/urban areas, standardized across participating countries to enable comparison, and the definitions used by other international organizations such as the World Bank.

School and classroom-related variables

The different measures of school and classroom conditions include class size, multigrade class, a class resource index, mathematics textbook availability for students, and mathematics textbook and teaching guide availability for teachers. Only the availability of the textbook and the guidebook for teachers seemed to affect student math scores. When the teacher had a textbook, average student test scores were roughly 39 points higher; when teachers had a guidebook, student scores were over 20 points higher. In the sample, over 95% of teachers had the textbook, but fewer than 60% had the associated guidebook for mathematics.

Teacher-related variables

None of the teacher characteristics included in the study (gender, age, experience, training, qualifications, or employment classification) had a statistically significant association with student math performance. This result is both surprising and disappointing since they suggest that some key policy levers are not working well. Of particular note, teacher training and qualifications do not seem to be associated with better math performance by students, which may warrant further analysis to see how these processes can be improved, and whether their costs are warranted given their limited effectiveness.

Student-related variables

Not surprisingly, student characteristics are of great importance for math scores. Female students, on average, had math scores about 14 points lower than male students. Student age also matters. The youngest student in the sample was 8, and the oldest was 20; the average age was 12. Older students have either been out of school for a period of time or held back to repeat grades. For each additional year of age, math scores fall by over 8 points.

To confirm the age effect, an alternate specification of the full regression with only students between the ages of 10 and 15 was estimated and the results remained robust. The coefficients on both the student age and grade repetition remained negative and statistically significant. The results were not surprising as excluded students (those under 10

or over 15) only make up a small portion of the population, about five per cent. Results of this estimation are available upon request.

In addition to the age effect, repeating at least one grade is associated with a 24-point fall in test scores for mathematics. Both age and grade repetition are likely the best indicators, available in the data, of a student's inherent scholastic aptitude, and thus serve as a partial control for innate ability. While a student's natural knowledge and ability are widely considered an important determinant of final performance, arguably, the conclusion for older students and students who have repeated at least one grade is that this relationship is being moderated by other factors (for example, school absenteeism).

One policy-relevant result of concern is the absence of an association between preschool or kindergarten attendance and better performance on math scores. Parents and school boards might want to consider ways that kindergarten can better prepare students for future studies.

Family-related variables

Finally, family characteristics (parent reading ability and SES index) affected student performance. Having both parents able to read (63% of the sample) is associated with a 14-point higher score on the math evaluation, while each additional point on the family's SES index (which ranges from 17 to 88, with an average of 53) raises math scores by around one point. These effects are fairly small in magnitude but are quite consistent and statistically strong.

Table 1: Estimation results for the mathematics assessment plausible values.

	Full Model		Reduced Model	
Explanatory Variable	**Coefficients**	**P-Values**	**Coefficients**	**P-Values**
Francophone region	9.250	0.462	-	
Urban	72.364***	< 0.000	71.482***	< 0.000
Community Development Index	-0.625	0.465	-	
Class size	0.020	0.890	-	
Multigrade class	-9.981	0.357	-	
Class Resource index	-0.636	0.568	-	
No math textbooks available	-7.025	0.624	-	
One math textbook per student	18.087	0.287	-	
Teacher has the math textbook	34.705†	0.097	39.121***	0.001
Teacher has the math guidebook	22.800*	0.035	20.466***	0.009
Teacher is female	3.901	0.725	-	
Teacher's age	-0.828	0.472	-	
Teacher's years of teaching	0.527	0.717	-	
Teacher trained, one year or less	21.238	0.240	-	
Teacher trained, two years or more	21.561	0.212	-	
Teacher has a professional qualification diploma	-13.053	0.486	-	
Teacher has a civil service contract	6.297	0.676	-	
Teacher has been contracted privately	6.271	0.672	-	
Teacher is a volunteer	2.955	0.836	-	
Student is female	-15.473**	0.004	-13.601***	0.003
Student's age	-8.278***	< 0.000	-8.711***	< 0.000
Student attended kindergarten	5.796	0.340		
Student has repeated at least one grade	-23.918**	< 0.000	-24.283***	< 0.000
Student's parents are both to read	13.066*	0.043	14.137**	0.019
Socioeconomic Status Index	0.942*	0.028	1.144***	0.003
Constant	540***	< 0.000	470***	< 0.000
Observations	2,593		3,152	
Average R-squared	0.401		0.375	

***, **, *, † indicate statistical significance for one-tailed tests at the .01, .025,0.05 and 0.1 levels, respectively.

To further analyse these results, we examined regressions using sub-samples defined by language, gender, and location. We chose these three as being the most interesting from a policy perspective; future work could focus on other, even smaller, subsamples, though the reliability of the results would be affected by sample size. The Francophone-Anglophone analysis indicates several important distinctions. We reviewed each of these to identify inductively potentially useful associations that could better explain student performance and highlight potentially useful policy instruments. In the educational system sub-samples, we noted that the urban effect, positive in both systems, was stronger in the Francophone system. Francophone student scores were also generally higher when teachers were trained, equipped with textbooks and guidebooks, and private (as opposed to being volunteers or in the civil service). Francophone females did worse than males, and Anglophone students generally did worse when they had attended kindergarten or had older teachers.

In the gender sub-samples, the effects of teachers having textbooks and parents being able to read appeared to be important for only male students. Male Francophone students had higher scores than their Anglophone counterparts, and male students appeared to do better with younger teachers. Finally, there was some troubling evidence that male students did slightly worse when their teachers had received select professional qualifications.

The last sub-sample separated out rural and urban locations. The difference in the urban effect between educational systems was evident here, too, as Francophone students appeared to perform slightly better than Anglophones in urban areas but not rural ones. Grade repetition was negatively associated with both urban and rural math test scores, but the effect was more pronounced in urban areas. Although rural schools have lower community development indices, smaller average class sizes, more multigrade classes, and lower-class resource scores, none of these factors had statistically significant associations with test scores in math. Student access to textbooks had significant positive effects on math scores for rural students, as did the presence of textbooks and guidebooks for their teachers. Female teachers, and teachers with select years of training as well as parents' reading ability, were associated with higher math test scores for students in rural areas. Finally, the troubling evidence of select teacher professional qualifications being associated with lower math scores was also present but only for urban students.

Since these indicative results appeared only in some sub-samples and were not tested jointly, we created interactive variables to see which of these effects remained statistically significant in the expanded full-sample model. We tested several versions of the models to ensure robustness. The findings generally corroborate earlier results, provide greater nuance than those in Table 1, and reiterate some interesting areas for attention by policymakers.

The effect of student age, grade repetition and socio-economic status remained robust with signs and magnitudes similar to those reported in Table 1. However, we chose to focus this discussion on the interaction coefficients that were consistently significant in alternate estimations we conducted. The estimations showed that lower scores for females turned out to be the result of better performance by Francophone males. The positive effect of teachers having

the math textbook is particularly pronounced for male and Francophone students. The positive association between math scores and private teachers was only present in the Francophone system. Also, having older teachers negatively impacted math scores in the Anglophone system and the negative effect of grade repetition remained prominent for urban students.

Further, the effects of attending kindergarten continued to be mixed and troubling. For Francophone students, attending kindergarten was associated with an increase in math scores. By contrast, attending kindergarten was associated with a drop in math scores for Anglophone students. This result points to a potential problem with either the kindergarten programs in Anglophone areas or the factors associated with putting Anglophone children into kindergarten. Finally, a significant negative effect of select teacher professional qualifications on math scores for male or urban students was not evident in the expanded full sample model results.

Summary of results and policy implications

The full sample, sub-sample and expanded full sample results generate a number of policy-relevant observations. First, the results generally highlight a nuanced and complementary contribution of both school and family factors, corroborating cross-country evidence highlighting the pivotal role of both schools and families in determining learning outcomes in low-income countries (for example, Gruitjers & Behrman, 2020; Allier-Gagneur & Gruijters, 2021).

Second, results also suggested that addressing the urban-rural gap in basic class resources such as textbooks would seem worthwhile, though the quality of teacher material in the Anglophone system is worth reviewing. Third, the poorer performance of Anglophone students with older teachers and the superior performance of Francophone students highlight the need for a closer assessment of the differences in teacher factors (particularly, training, credentialing, experience, retention and renumeration) across educational systems to identify promising teacher-related policy levers.

Fourth, the negative effect of grade repetition speaks to the need to target disadvantaged groups with new methods and resources to reduce the extent to which they are being left behind. Fifth, the fact that kindergarten attendance seemed to have harmful effects on the Anglophone system suggests the need for a serious investigation as to the cause of such a statistical association.

Finally, the weaker performance of female students in math, a result often found elsewhere, identifies another potential target for education policy reform. More intriguing, however, is that the disparate performance between males and females actually appears to reflect the superior performance of Francophone males; sources of this advantage might be worth examining further to identify practices that may improve the scores of Anglophone and Francophone females.

Conclusion

Mathematics is a fundamental skill for students and a key determinant of national economic growth and well-being. Low-income countries, in particular, must use their limited resources efficiently in order to provide the best educational experience possible for their student population. Weaknesses in the system of mathematics education are likely to be country-specific, and our study of Cameroon identifies several areas of concern.

Using standardized test scores in mathematics from the PASEC assessment, our analysis generally indicated that both school and family factors matter. The results also revealed that educational system, gender and location each play a role in determining mathematics performance. Further, the results suggested that resources used for providing kindergarten require additional scrutiny, particularly in the Anglophone sector. While most teacher factors did not seem to be consistently associated with student performance, there was some evidence of differences in mathematics performance based on teacher age and type across education sub-systems.

Additional work is required to understand more completely the education production function in mathematics for Cameroon, especially longitudinal analyses. The PASEC assessment process also allows for more detailed comparative studies of countries to understand the common problems in mathematics education in SSA and to identify best practices that can inform all countries in the region.

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A review of research on learning support in mathematics education in Sub-Saharan Africa: The case of Botswana, Namibia, Zambia and Zimbabwe.

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Abstract

All learners have different educational needs, and learners taking mathematics are no exception. This review paper focuses on the recent studies in Sub-Saharan Africa in four countries: Namibia, Botswana, Zimbabwe, and Zambia in mathematics education. These countries perform poorly in mathematics according to all SACMEQ (Southern and Eastern Africa Consortium for Monitoring Educational Quality) reports, though there has been an incremental improvement. The methodology of the study incorporated research studies on mathematics learning disabilities and difficulties, however, only limited research was found in Namibia and none in the other countries using this terminology. In all four countries, the inclusive education policies do not specifically mention MLD. As a result, this study was expanded to include learners' performance in mathematics in general. The articles sought were research-based articles and were mainly empirical for the period 2010 to 2021. Most research focuses on problems related to poor performance of learners, teachers' and learners' perceptions and attitudes, and teacher training in mathematics education. These issues are compared and contrasted in different countries. The limited research found on MLD focuses on beliefs, misconceptions, barriers in teaching and learning mathematics, and learning support. We recommend that in these four countries, more research is needed on learners with MLD within the general mathematics population. The focus area should include early identification of learners with MLD, support based on the diagnosed learning needs, and teacher training on MLD, appropriate teaching and learning strategies.

1. Introduction

Over the past decade, Mathematics Learning Difficulties (MLD) attracted the attention of many researchers and educators, focusing on a better understanding of the construct; however, some African countries are under-represented in such studies. Therefore, this article reviews studies and government documents about learning support in mathematics education in four countries in Sub-Saharan Africa, namely Botswana, Namibia, Zambia and Zimbabwe. These countries were selected since they form part of SADC (Southern African Development Community), whose main objectives are to achieve economic development, peace, security and growth, as well as alleviate poverty, enhance the standard and quality of life of the peoples of Southern Africa and support the socially disadvantaged through regional integration (SADC, 2012). The countries border one another and are among the smaller populations in SADC. In addition, their histories are intertwined with British colonialism, and upon their political independence, English became their official language. As such, their initial education systems after their independence have been largely based on the British education system. This review focuses on mathematics education, specifically MLD and disabilities, in these countries.

A comparative study was undertaken to incorporate previous research studies conducted in these countries. The focus was on i) terminology employed by researchers (in each country), ii) the countries' policies, and iii) empirical research related to MLD and disabilities and inclusive education, which has been conducted in slightly more than the last decade. These issues have been compared and contrasted.

The order of this article is as follows: 1) an introduction to the countries; 2) a comparison structure of education that includes teacher training and mathematics assessment, both locally and internationally; 3) policies on inclusive education and MLD and disabilities; 4) research conducted on MLD and disabilities. The article concludes with an emphasis on the review's findings and suggestions for future studies.

1.1 Introduction to countries

The map of Southern Africa below highlights the proximity of Botswana, Namibia, Zambia and Zimbabwe and the rare, four-nation, purported quadripoint where they meet. Table 1 provides background information regarding the geography and population of the four countries in the Southern African Development Community (SADC) that are discussed in this article.

In Table 1, it is apparent that these four neighbouring SADC countries have a wide range in their populations. Botswana and Namibia have very small populations and, similarly, small population densities, while the Zambia and Zimbabwe populations and population densities are about six times larger.

Figure 1: Location of Botswana, Namibia, Zambia, and Zimbabwe in Africa (Quadripoint, 2022).

Table 1: Introduction to countries.

Countries	Botswana	Namibia	Zambia	Zimbabwe
Population (2 August 2021)	2,401,764	2,590,585	18,938,504	15,096,708
Country size	581,730 km²	825,615 km²	752,614 km²	390,757 km²
Population density	4/km²	3/km²	25/km²	39/km²

1.2 The education structure in general

1.2.1 Education structure in general

Table 2 presents the education systems of the four countries, as well as the Grades in which mathematics is offered as a subject.

Table 2: The general education structure.

		COUNTRIES			
		BOTSWANA	**NAMIBIA**	**ZAMBIA**	**ZIMBABWE**
The education system	**School phases**	*2½- 6 years early childhood education *Primary School (Grades 1-7) *Junior Secondary Education (Grades 8-10) *Senior Secondary Education (Grades 11-12)	*Pre-primary (Grade 0) *Junior primary (Grades 1-3) *Senior primary (Grades 4-7) *Junior secondary (Grades 8-9) *Senior secondary (Grades 10-11) *Advanced subsidiary (Grade 12)	*Early childhood (3-6 years) *Primary education (Grades 1-7) *Secondary education (Grades 8-12)	*Two years of Pre-primary school (3-5 years) *Primary education (Grades 1-7) *Lower Secondary school Ordinary Level (Forms I-IV) *Upper Secondary school Advanced Level (Forms V-VI)
	School age	6-17	6-18	7-18	6-17
	Learner enrolment	103.2% (2015)	124.2% (2018)	98.7% (2017)	109.8% (2013)
	Learner-teacher ratio	Primary: 25 (2022)	Primary: 25 (2018)	Primary: 45 (2022)	Primary: 36 (2013)
	Medium of instruction (MOI) according to the language policy	Setswana is the MOI in Grade 1 with English as the 2nd language. From Grade 2 this is reversed	Mother tongue (14 languages) from pre-primary to Grade 3 with English as the 2nd language. From Grade 4 this is reversed.	Mother tongue (7 languages) from Pre-primary to Grade 3 with English as the 2nd language. From Grade 4 this is reversed.	Mother tongue (2 languages) from Pre-primary to Grade 3 with English as the 2nd language. From Grade 4 this is reversed.
	National examinations	*Grade 7 Primary School Leaving Examination (PSLE) *Grade 10 Junior Certificate Examination (JCE) *Grade 12 Botswana General Certificate of Secondary Examination (BGCSE)	Grade 11 (NSSCO) and Grade 12 (AS)	Grades 7, 9 and 12	*Grade 7 Certificate *Zimbabwe Junior Certificate, Grade 9 *General Certificate of Education (GCE) at Ordinary Level (O-level) *Zimbabwe General Certificate of Education (GCE) at Advanced Level (A-level)
Mathematics offered as a compulsory subject		From Primary to Grade 10	Compulsory from Pre-primary to Grade 11 Grade 12 (AS) – elective	Mathematics is compulsory (from Primary to GCE)	Mathematics compulsory (from Primary to O-level)

Table 2 indicates that all four countries have a structured, early childhood education system. In Namibia, the Pre-primary class, preceding Grade 1, forms part of the formal school system. Primary education spans Grades 1 to 7. Namibia, furthermore, divides this phase into Junior Primary and Senior Primary. Secondary education from Grades 8 to 12 is structured differently in all four countries. Zambia is the only country where there is no division into different phases. Learners in Botswana and Zambia exit formal schooling with

a national certificate in Grade 12, while in Namibia, this is possible in Grade 11 with a certificate in Ordinary Level and, in Grade 12, with an Advanced Subsidiary Level qualification. Zimbabwe is the only country that has a 13th school year at the secondary level. They also make use of the term Forms rather than Grades. Forms I-IV culminate in a certificate at Ordinary Level, while Forms V-VI provide an Advanced Level certificate.

There is not much difference between the four countries in terms of typical features when it comes to learning conditions. For instance, there are state (public), private and international schools in all countries, with a large number of learners attending public schools. International schools have their academic calendar based on the country of their origin. While all four countries have excellent learner enrollment rates, their learner-teacher ratios differ somewhat. The recommended class size for primary schools in all countries is between 25 and 45, with Namibia having the lowest class size. However, in practice, some classes could have as many as 65 or 60 learners, for instance, in Namibia and Zambia, respectively. Moreover, there are variations in average class size based on regions, especially in Namibia and Zambia. Kekhani-Mhoney from Namibia echoes the findings of Harfitt (2012), who found that learners in large classes do not receive much individual attention from teachers. Individual attention to students is reduced, negatively affecting Botswana's academic achievements (Adeyemi et al., 2003).

Countries with notably widened gaps between rural and urban schools in the proportion of Grade 6 pupils who enrolled late into primary schooling by two or more years are Namibia (20%) and Zambia (19%). The gap in Zimbabwe between urban and rural remains small at 1%. In Namibia, from 2013 to 2019, there has been an average annual growth rate of 9.3% in the number of schools in the country. However, this rate is higher in primary than in secondary schools because, in sparsely populated rural areas, there is usually a high number of primary school learners, but not all learners transition from upper primary to junior secondary. Reasons could be grade repetition and a high drop-out rate. This is the case in Zambia and Namibia. For example, a greater proportion of Namibian Grade 6 learners attending schools located in rural areas tend to repeat a grade than those in urban areas (EMIS, 2019).

The proportion of school dropouts for 2021 in primary school in Zimbabwe is lower at 0.53%, compared to secondary school, which is 4.67%. In comparison, the average dropout rate for Namibia in 2019 was 1.8%. This represents 13,375 learners (out of a total of 756,994 learners), of whom 6,604 (49.4%) are female. The major reason for female learner dropout is pregnancy (23.3%). According to EMIS, this figure could well be higher if schools reliably reported on the incidence of pregnancies. Furthermore, a reasonably large number of learners dropped out because of the long distance between school and home. Some learners were recorded as leaving school for "unknown reasons" (EMIS, 2019).

According to the different Language Policies, the medium of instruction for the Lower Primary phase should be the local languages with English as the second language. The situation is reversed from the Upper Primary phase. It appears that these language policies are likely to be implemented more effectively in rural than urban areas due to learner diversity in the cities and towns. Although the language policies in these countries promote mother-tongue education in the lower grades, not all learners are being taught in their mother tongue. Two factors may contribute to this: (i) learners residing in areas where their mother tongue is not offered as a medium of instruction due to insufficient numbers of learners; and (ii) parents' decision either to collectively introduce a different medium of instruction in a school or to enroll their child in a school with a different medium of instruction. With regard to mathematics, some terminologies are difficult to translate into local languages. This becomes a challenge for learners to learn mathematics with understanding, and it may negatively affect their academic performance in the subject.

In all four countries, mathematics is compulsory in most Grades. In Botswana, it is a compulsory subject up to Grade 10 whereas, in Namibia and Zimbabwe, it is compulsory up to Ordinary Level. In these countries, learners can take Advanced Subsidiary (Namibia) or Advanced Level Mathematics as an elective in their next school year. In Zambia, mathematics is compulsory for up to Grade 12 for all learners.

1.2.2 Teacher training education

Table 3 below presents teacher training, in general, and mathematics education training, in particular, in the four different countries.

Table 3: Teacher training.

		COUNTRIES			
		BOTSWANA	**NAMIBIA**	**ZAMBIA**	**ZIMBABWE**
Teaching Qualifications	**Minimum qualification required**	A 3-year Diploma	A 3-year Diploma	A 3-year Diploma	A 2-year Certificate in Primary or 3-year Diploma in Secondary Level
	Qualification offered	*A 4-year B.ED Degree (Prim/Sec Educ.) A 3-Year Diploma (Primary or Junior Secondary)	A 4-year B.Ed Degree at University Other institutions offer Diplomas in Education	A 4-year Degree and 3-year Diploma	A 3year B.ED Degree (General) A 4-year B. Ed Degree (Honours)
	Minimum training entry requirements to become a Maths teacher	O-Level (BGCSE) or equivalent; should have a minimum of C (60%) in English Language and a minimum of D (50%) in Mathematics and/or Science	AS Level/Grade 12 with a minimum of C (60%) in English and Mathematics	O-level/General Certificate of Education with minimum 45%	O-Level and/or A-Level with a pass in Mathematics (minimum C) 60%
Mathematics education training	**Mathematics education modules**	***Bachelor of Primary Education:*** *Maths Education I, II *Introduction to Numeracy and Science for Teachers *Teaching Number System *Teaching School Mathematics *Geometry for Primary School Teachers *The Use of Technology in Teaching Primary Mathematics	***B.ED (Pre- and Lower Primary) (Honours)*** *Numeracy and Mathematics Education I-III *Learning Support in the Mathematics Classroom ***B.ED (Upper Primary) (Honours)*** *Introduction to Mathematics Education *Mathematics Education I-III ***B.Ed (Secondary)(Honours)*** *Teaching Methods of Mathematics *Statistics for Educators *Educational Research Project in Mathematics	***Bachelor of Education (Mathematics and Science Education):*** *Mathematics Teaching Methods *Mathematics Education Project *Mathematics Education	***Bachelor of Science Education Honours Degree (Mathematics):*** *Theoretical Foundations of Education *Pre-school & Primary School Mathematics Experience *Numerical Methods *Pedagogics in the Teaching Subject (Mathematics)
	MLD training	No MLD training	*Pre-Service: Learning Support in the Mathematics Classroom *In-service training: Learning support training with Learning Support Resource book	No MLD training	In-service training: *Cluster-based support networks for Mathematics teachers. *Teacher capacity building on special needs and learning disabilities. *Subject associations on Mathematics learning disability.
Inclusive education modules offered		No specific module offered on Inclusive Education	*Inclusive Education I (compulsory for all education programmes) *Inclusive Education II offered as an elective for 4th year students as a career specialisation	*Diploma trainee teachers all do Inclusive Education *Degree trainee teachers – depends on the course	*Inclusive Education (compulsory for both Primary and Secondary Teaching training)

Table 3 above indicates that all four countries accept a three-year Diploma as the minimum teaching qualification; however, tertiary institutions also offer a four-year Diploma and four-year Bachelor Degree with Honors for teachers in different specializations. Entry requirements for teacher training vary across the four countries. Most of the programmes offer teaching methods in Mathematics and Mathematics Education modules. None of the countries specifically train in MLD. Only Namibia's B.Ed. Pre- and Lower Primary programmes include a module for learning support in mathematics. Namibia and Zimbabwe provide in-service training for teachers and education practitioners in learning support. It appears that Botswana and Zambia

do not provide training in learning support in mathematics. Inclusive Education, as a module is offered in teacher training in these countries to varying degrees, except for Botswana.

1.2.3 Mathematics assessment

Table 4 presents how mathematics is assessed at school, national and international levels in the four countries studied.

Table 4: Mathematics assessment.

	Countries			
	Botswana	Namibia	Zambia	Zimbabwe
At school level	Quizzes, topic tests, end-of-term tests and mock examinations.	Homework, tests, exams and projects as part of continuous assessment	Test, exams and continuous assessment	Homework, tests, exams and projects as part of continuous assessment
At national level	*National Achievement Tests, Grade 4 *The students only take standardised examinations when they complete Primary, Junior and Senior Secondary School Levels in Grades 7, 10 and 12	*Namibian Standardised Tests (NSAT) in Grades 5 and 7 *National exams for Grades 11 and 12 from 2020 (new curriculum); (previously Grades 10 and 12)	National exams for Grades 7, 9 and 12	National exams: Primary Level Grade 7, Form 4 (O-level) and Forms 5 and 6 (A-Level)
International level	SACMEQ	SACMEQ	SACMEQ, PISA	SACMEQ

Table 4 indicates that assessments in mathematics focus on homework, tests, projects and exams at the school level. National assessments typically comprise examinations at different Grade levels for different countries. Two countries also administer standardised achievement tests, namely Botswana in Grade 4 and Namibia in Grades 5 and 7. All countries have been involved in the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ), which assesses performance in mathematics and reading, at the international level. Zambia has also been involved in the Programme for International Student Assessment (PISA) which assesses scholastic performance in mathematics, science and reading.

Comparison of international assessment (SACMEQ reports)

The Figures below present a closer look at the SACMEQ assessment scores for mathematics. Figure 2 examines the mathematics scores for Grade 6 learners who were assessed, while Figure 3 looks at the mathematics scores for the teachers of these learners.

The domains for the mathematics assessment consisted of Numbers (operations and number line, square roots, rounding and place value, significant figures, fractions, percentages, and ratios), Measurement (related to distance, length, area, capacity, money, and time) and Space-Data (geometric shapes, charts-bar, pie, and line, and tables of data). Eight skill levels ranged from pre-numeracy through emergent-, basic-, beginning-, and competent numeracy, followed by mathematically-skilled, problem solving, and abstract problem-solving.

Both the reading and mathematics data matrices were analyzed using computer software that applied the Rasch Model of measurement. The test items were calibrated by calculating the Rasch difficulty values for each item. In order to ensure that it was fair to compare all countries on the total test score, the correlations between the 'essential' items and all items were calculated in every country, and in all cases, the results were between 0.98 and 1.00. The mean for all SACMEQ countries was set at 500, and the standard deviation at 100.

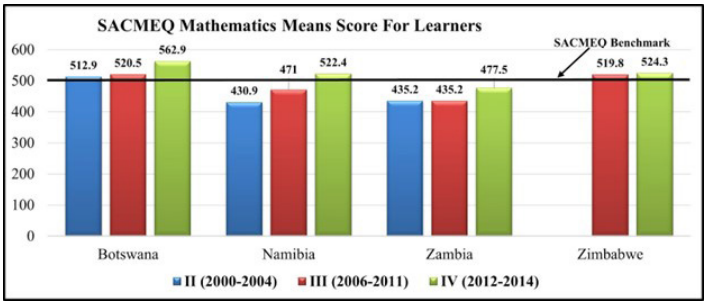

Figure 2: SACMEQ mathematics mean score for learners. Note: SACMEQ mean average 500 (benchmark).

Mathematics assessment did not occur in SACMEQ I; only reading assessment was conducted. Zimbabwe did not participate in SACMEQ II. Figure 1 indicates that the general trend for those countries whose learners participated in more than one SACMEQ, the mathematics scores went upwards. Botswana and Zimbabwe have consistently reached the SACMEQ benchmark; however, Namibian learners have only reached the benchmark of 500 in the 4th assessment, whereas Zambia has not reached this level as yet.

Specifically, in SACMEQ II, the average score for learners in all the countries involved was set at 500. Only Botswana (512) was above that average (Zimbabwe did not participate). The SACMEQ III mathematics average was 510, and Botswana and Zimbabwe were above the average. The average for SACMEQ IV (2013) was 542 points, and once again, Botswana (562) was the only country that surpassed that average.

In SACMEQ II, out of the 14 countries, Botswana was 7th, Zambia was 12th, and Namibia was last in 14th place (Zimbabwe did not participate). In SACMEQ III, 15 countries participated, and Botswana was 6th, Zimbabwe 7th, Namibia was 13th, and Zambia was last in 15th place. Fourteen countries participated in SACMEQ IV, with Botswana in 5th place, Zimbabwe 7th again, Namibia 9th, and Zambia last again in 14th place. Consistently Mauritius and Kenya were first and second across all SACMEQs.

In all SACMEQ mathematics assessments, rural learners fared worse than their urban counterparts in the focus countries. Similarly, the scores of learners with low socioeconomic status (SES) were, on average, way below those having high SES. With regard to differences in gender, the results are mixed. Girls were better than boys in all mathematics assessments in Botswana. In Namibia and Zambia, it was the exact opposite, and boys were better. The one complete Zimbabwe statistics we could access for gender (SACMEQ IV) showed that girls did better than boys.

Figure 2 indicates that, in those countries that participated in the mathematics assessment, teachers scored above the 500 benchmark. Typically, the trend over the years has

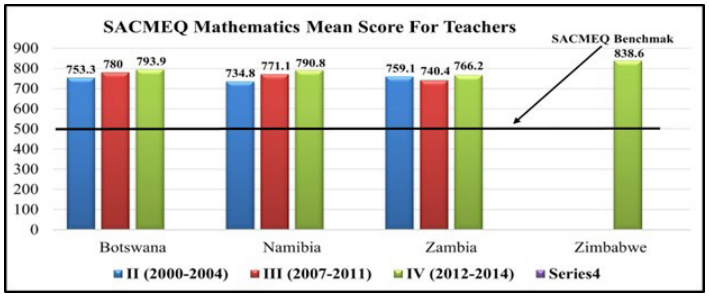

Figure 3: SACMEQ mathematics mean score for teachers.

been upward, although Zambian teachers showed a dip in SACMEQ III. Zimbabwe's first mathematics score for teachers in SACMEQ IV was the highest overall score among the four countries.

According to Gustafsson (2019), international assessment results such as SACMEQ, TIMSS (Trends in International Mathematics and Science Study) and LLECE (Latin-American Laboratory for Assessment of the Quality of Education) are used to inform education policy debates and many times implementation of changes in education, specifically classroom practices. In analyzing the microdata of these assessments, he, however, is of the opinion that the floor effects are not properly taken into consideration, although they (SACMEQ, LLECE) were designed for developing countries. As such, disadvantaged learners who consistently score zero are not sufficiently catered for. To counteract this, he suggests that easier multiple-choice items and more constructed response items should be added to these assessments.

It is these floor effects in these assessments that make them difficult to link and compare in the interest of UNESCO Institute for Statistics (UIS) and World Bank. In addition, comparison of mathematics assessments of the same country but across different grades can also be problematic, especially if factors such as the percentage of out-school-children and grade repetition differ across the grades. Gustafsson (2019) cites Altinok et al.'s (2018) example of Colombia's LLECE 1997 Grade 6 mathematics link to TIMSS 1995 Grade 8 mathematics. A further area of concern was raised in that the original data must truly represent each country. SACMEQ not only assesses reading and mathematics, but goes into much detail in assessing, monitoring and evaluating the conditions of schooling and the quality of education. It is these conditions that make it difficult to compare the mathematics results of an African country to an Asian or European country.

An article by Postlewaite (2004) reviewed the work carried out by the International Association for the Evaluation of Educational Achievement (IEA, with TIMSS and PIRLS), Programme for International Student Assessment (PISA), SACMEQ and LLECE in order to identify their aims and the target populations they used, what they have found about the quality of education in various countries and across time, how they treated the differences in student backgrounds in their analyses, how the results were being used, what impact they were having in the various countries, and finally something about the strengths and limitations of the different studies. The four studies did not compare scores with each other. PISA was for 15 year-olds and the IEA concentrated on the end of primary school so that it could not be expected that they could have a common scale. There could have been a common scale for reading for IEA, SACMEQ and LLECE and this would have enabled the countries to judge how far they were from each other, but since each created scales for their own group of countries this was not possible.

The introductory comparison between the four Sub-Saharan African countries indicates more similarities than differences in terms of their education systems and teacher training, particularly in mathematics (see Tables 1 to 4 and Figures 2 and 3). Based on these observations and in a further investigation of mathematics learning and teaching, this review sheds light on how MLD and disabilities are defined in these countries. Furthermore, it compares the educational support systems of learners with MLD in the inclusive mathematics classrooms of the four countries. Therefore, in the following sections, policies on inclusive education and MLD and disabilities (including assessment and support), as well as the research reviewed (including defining MLD and disabilities and challenges related to MLD and poor performance in mathematics), are presented.

2. Policies on inclusive education and learning difficulties and disabilities in mathematics

The policies on inclusive education in the four countries are rather generalized and focus on learners with learning difficulties (LD) or other forms of disabilities. For instance, the Botswana inclusive education policy generally defines an inclusive education system as one that includes and meets the needs of all learners, including those with special educational needs, and that teachers should be able to meet the needs of such learners in a regular or ordinary classroom (Government of Botswana, 2011; Moswela et al., 2009). Special education needs, of which MLD ought to form a part, are defined as education for disadvantaged and vulnerable learners.

Furthermore, the Namibian sector policy on inclusive education aims to ensure that the education system becomes inclusive, sensitive and responsive to the needs of all children and that all children receive an education. It has a specific focus on children and young people who have been, or are more likely to be, educationally marginalized. These educationally marginalized children may be children with learning difficulties. The Namibian inclusive education policy shifts the focus from blaming the child for difficulties in learning to the interaction between the learner and his/her environment (Ministry of Education, 2013).

In Zambia, inclusive education entails the full participation of all learners in the learning process (Kasongole & Muzata, 2020) since the Ministry of Education's policy aims to allow children with special educational needs to remain in regular schools. It targets marginalized children, such as Learners with Special Education Needs (LSEN), Orphans and Vulnerable Children (OVC), across all education levels (Hamusunga, 2012). In Zambian schools, all learners are taught together and are given the same instruction and

support to meet appropriate learner outcomes (Florian, 1998) because in every class or Grade there could be children with differing educational needs, such as those with difficulties in reading, mathematical calculation and learning new motor skills (Abosi, 2007).

In Zimbabwe, inclusive education is defined as an effort to meet the needs of every child, including those with disabilities, in regular schools (Singh, 2014). The inclusive education policy also addresses and responds to the varying needs of all children by increasing participation in learning and reducing exclusion in and from the education system (Katsande, 2019). Even though the policy requires all learners, irrespective of disability, to belong, participate meaningfully and learn at their local school (Kearney, 2011), this has resulted in the ineffective implementation of inclusive education where learners do not receive the support they require (Chidarikire, 2021).

As can be seen from the discussion above, the inclusive education policies of the four countries are similar in that they strive to include learners, with the support they need, in the least restrictive education environments. These ideals are not always implemented in the manner that the policies recommend. The following sub-sections discuss implementation in terms of assessment and learning support in mathematics.

2.1 Mathematics assessment

There appear to be no clear assessment tools available in MLD in all four countries; however, Botswana and Namibia have what could be linked to assessment tools available in documents (e.g. *Learning Support Resource Book* – Namibia) (Ministry of Education, 2014). The assessment tools outlined in Botswana and Namibia's documents could assist learners with LD and could possibly include MLD. While the documents outline procedures to be followed, the implementation of assessment has been proven by researchers in both Botswana and Namibia to be a challenge.

On the one hand, Botswana has an Assessment Centre that diagnoses the learning needs of learners with special learning needs at primary schools. The Assessment Centre is responsible for placement and/or instructional modification in regular primary schools. However, a study was conducted to investigate the role and functions of the Botswana Assessment Centre in diagnosing learning needs (Mangope et al., 2012). The same study also investigated issues and challenges faced by learners with special needs who are not assessed for placement and/or instructional modification in regular primary schools. The results revealed that the centre was unable to assess all learners who required assessment; furthermore, there was a long waiting time for assessments. The results also revealed that although many schools had School Intervention Teams who were responsible for referring learners for assessment, in some schools, the role of teams was unclear (Mangope et al., 2012)

On the other hand, Namibia, under its Ministry of Education, Arts and Culture, the Directorate of Programmes and Quality Assurance (PQA), is mandated to formulate overall policies for general, formal education, as well as regulatory frameworks and guidelines that support good practices at school and management level. The Directorate has two closely related divisions, namely the Division of Special Programmes and Schools (DSPS) and the Division: Diagnostic, Advisory and Training Services (DATS). DSPS is responsible for the national provision of assistance to educationally marginalized children through special needs education. DATS caters for guidance, counselling and support services, especially for educational, psychological and social assessment. Despite their (DATS and DSPS) mandates, neither division claims to assess specific learning difficulties, such as mathematics difficulties/disabilities, according to the Ministry's website (https://www.moe.gov.na/m_dir_directorates.php – Ministry of Education Arts and Culture, 2018). In a report on *Assessing inclusive education in practice in Namibia* (Nambira et al., 2009), the assessment of learners with specific learning difficulties was not discussed. Learning support was discussed in terms of the placement of learners with disabilities at resource schools and units (former special schools and special units) and learning support classes in mainstream schools (former special classes) but not as a diagnostic process that leads to intervention. Moreover, in the report that focused on learners' performance in mathematics at the Upper Primary phase, the 69 mentions of assessment were solely related to mathematics content performance as related to tests and examinations. The term, intervention, was mentioned only once. As expected, there was no mention in the report of assessment as related to a diagnosis that should lead to intervention.

In a study in Zambia, it was found that several teachers did not seem to know the characteristics of learners with learning disabilities. This failure could make it difficult for teachers to identify and assess learners with LD. As a result, there would be no support for such learners (Kasongole & Muzata, 2020).

In 2003 a standardized test battery for *Basic Numerical and Calculation Abilities* (BANUCA) for Grades 1-4 (n>2600) was published in Zambia. The test is targeted for screening MLD. The Zambian localized version has instructions in English, Chitonga, Cinyanja, Icibemba, Kiikaonde, Lunda, Luvale and Silozi. It was developed and standardized in a project on special education as a product by the Ministry of Education and international partners (Räsänen & Chilala, 2003).

In Zimbabwe, the detection of learners with LD has also not been clearly explained by experts (Mutepfa et al., 2012); however, learners are defined to have LD if they have average and/or above-average intelligence but lag at least two years behind in a subject like mathematics. Some locally produced tests have been utilized in the identification of learners with LD but the authorship is unknown (Kaputa, 2016). There appear to be no clear guidelines on how the identification and assessment of learners with disabilities should be undertaken, except that the Special Needs Education and School Psychological Services will provide staff development in different ways to handle such learners. It would appear that the current aim of assessment of LD (whether it includes mathematics learning difficulties or not) is focused on learner placement rather than on diagnosis and subsequent intervention. The question is, thus, how are

learners with MLD supported in these countries?

2.2 Learning support

Learning support in Botswana, Namibia and Zambia is conducted by class or subject teachers, whether or not they have been trained during pre-service training to offer the needed support. When teachers have not been trained, they can be inducted in ways to support their learners utilising continuous professional development training. Thus, learning support remains the teachers' responsibility.

The inclusive education policy in Namibia recommends that each school should establish Learning Support Groups (LSG). Ideally, at least one Namibian teacher in each school needs to develop some expertise to deal with the more common difficulties and disabilities that learners experience. These teachers would also act as resource persons in their schools. Thus, teachers with expertise in mathematics learning would be the appropriate staff members to lead an LSG that is focused on mathematics learning difficulties.

In Zimbabwe, learning support is offered by qualified, special needs teachers, learner welfare, psychological services and the special needs education department, among others. They build the capacity of other teachers to tackle mathematics learning difficulties, develop appropriate teaching and learning materials for learners with diverse needs and provide advice on learner welfare issues, as well as adapt the general curriculum to meet individual learner needs (Ministry of Primary and Secondary Education, 2021). Mathematics teachers in three of the countries (Botswana, Namibia and Zambia) are required to support their learners with learning difficulties. In Zimbabwe, this responsibility is offered by trained educational practitioners.

3. The research conducted on MLD and inclusive education

This section gives an overview and synthesis of the research on mathematics learning difficulties (MLD) and disabilities in the Sub-Saharan African countries of Botswana, Namibia, Zambia and Zimbabwe.

3.1 Defining mathematics learning difficulties and disabilities

According to Kasongole and Muzata (2020), anyone can learn at her or his own pace and could be intelligent and/or have difficulties in a certain domain. Scholars in the field of mathematics education employ different terms for students who experience difficulties in mathematics, such as mathematics difficulties, mathematics disabilities and dyscalculia, based on the context of their study.

The policies on inclusive education in all four countries under review have not defined mathematics learning difficulties and disabilities (MLD), and there is limited research on MLD. In the Botswanan context, MLD is not defined, although the education of learners with disabilities started more than 40 years ago. Learners with Learning Difficulties (LD) are referred to as those who have mild to moderate intellectual disabilities, mostly found in regular schools. Botswanan teachers sometimes refer to learners with LD as slow learners or underachievers (Otukile-Mongwaketse, 2011).

At the time this article was written, three Namibian studies (Anderson, 2013; Hamukwaya, 2019; Hamukwaya & Haser, 2021) were identified to have employed terms that describe MLD. The three authors employed specific terminology related to mathematics learning difficulties, mathematics learning disabilities and/or dyscalculia in their research by drawing from the definitions of international studies. While these authors provided lengthy definitions of MLD by drawing from the definitions of international experts, none were able to provide a Namibian definition of MLD. Furthermore, Namibian official and unofficial documents that were scrutinized did not reveal any specific definition of MLD. Similarly, a Zimbabwean study defined and employed the term, dyscalculia, but it was not defined in Zimbabwean documents (Mataruse, 2002).

Zambian scholars employed the term 'learning disabilities', and studies of this nature are increasing in their education system (Chirwa, 2011; Muwana & Ostrosky, 2014). LD is defined as heterogeneous in nature, and teachers were still equating definitions of LD to that of physical and other disabilities. They, furthermore, did not demonstrate a basic understanding of the concept (Kasongole & Muzata, 2020). The studies reviewed did not reveal any definition of MLD.

In conclusion, the research studies reviewed employed MLD-related terminologies, but these terminologies did not reflect the current terminologies employed in official policies in their countries. Employing terminologies, such as learning difficulties and learning disabilities when referring to mathematics-related problems, appear to be the more common practice in all four countries. Therefore, this article was expanded to include research focused on problems related to the poor performance of learners in mathematics.

3.2 Challenges related to MLD and disabilities

This section examines the challenges related to MLD and disabilities that yield poor performance in mathematics as indicated by the reviewed literature relating to the four countries. Issues that were discussed by researchers include the lack of mathematical knowledge and skills, teachers' limited understanding of inclusive education, unfavorable teaching and learning conditions and a shortage of teaching and learning materials. Further aspects that came to the fore were curriculum issues, inadequate teacher training, beliefs about mathematics education and learners' interest in learning mathematics, as well as the lack of parental involvement.

Lack of mathematical knowledge and skills. Learners' lack of mathematical knowledge and skills was a common challenge in all four countries. The Examinations Council of Zambia (2018) reports high failure rates related to learners' inadequate understanding and comprehension of mathematical concepts. According to Moyo (2020), Zambian learners who failed to grasp mathematical knowledge and

skills often experienced learning difficulties in other subjects in which mathematical concepts were also employed. A study by Tshabalala and Ncube (2012) reveals that the causes of poor performance in mathematics in Zimbabwean rural secondary schools included a poor grounding in the subject at lower levels. In addition, Namibian research shows that learners who lacked a strong knowledge base were likely to experience MLD in the upper Grades (Hamukwaya & Haser, 2021).

Research also found that some teachers lacked the knowledge and skills needed for teaching mathematics (e.g. Otukile-Mongwaketse, 2011) and they, therefore, found it difficult to support learners with MLD and disabilities. Incompetence in teaching mathematics is believed by Namibian teachers to be one of the factors contributing to MLD that could cause learning problems (Hamukwaya, 2019). Furthermore, some Zimbabwean teachers lacked the appropriate pedagogy to deliver effective teaching due to poor practical instruction (Mupa & Chinooneka, 2015). Similarly, (Mukuka et al., 2020) argue that teachers' instructional and assessment approaches have constrained learners' success in mathematics in Zambian schools.

Teachers lack understanding of inclusive education. Even though the four countries each adopted a policy of inclusive education, they still face several challenges. Otukile-Mongwaketse (2011) looked at how Botswanan teachers implemented inclusive education in their classrooms and what teachers did to differentiate between learners with and those without LD. Findings indicate that learners with LD were not given those learning opportunities that would allow them to participate in the teaching and learning process. According to Morapedi (2018), teachers' understanding of inclusive education does not seem to fit the national requirements regarding the employment of learner-centred learning approaches; furthermore, it appears that they did not accept all learners as individuals. Kasongole and Muzata (2020) acknowledge the presence of Zambian learners with learning disabilities, but posit that teachers did not demonstrate an understanding of the concept despite attending continued professional educational development training. This indicates that learners with learning disabilities did not receive attention in inclusive education classrooms because of teachers' limited understanding of the concept of learning disabilities.

Similarly, some teachers demonstrated negative attitudes towards learners with learning disabilities because they had little knowledge of learning disabilities and, therefore, found it difficult to support those learners (Makamure, 2016; Miyoba, 2014). Consequently, inclusive education is framed rather as a theory than a practice that should be implemented (Chimhonyo et al., 2011).

Unfavorable teaching and learning conditions and environments. Botswana, Zambia and Zimbabwe reveal some teaching and learning conditions and environments that frustrated teachers. For instance, a too-heavy workload and overcrowded classrooms made it difficult to attend to individual learners' needs (Chirwa, 2011; Mukhopadhyay et al., 2012; Muwana & Ostrosky, 2014; Riehl, 2013).

Shortage of teaching and learning materials. There appears to be a shortage of human and teaching resources in Botswana, Zambia and Zimbabwe that obstruct the support of learners with disabilities and hinder the full implementation of inclusive education (Habulezi et al., 2016; Ngulube et al., 2020; Tshabalala & Ncube, 2012).

Curriculum issues. Several curriculum-related factors leading to poor performance and challenges in providing learning support were found in all countries. The literature mentions challenges, such as English as the medium of instruction in Namibia, that makes mathematical word problems, as well as reading questions with understanding, problematic for many learners (Hamukwaya, 2019). In addition, learners in Botswana, Zambia and Zimbabwe experienced learning challenges related to the curriculum because curricula were competitive and examination-oriented (Mpofu & Molosiwa, 2017; Muzata, 2015).

Inadequate teacher training. Research indicates that mathematics education does not receive much attention in Zimbabwe at college level during teacher training; they become mathematics content specialists rather than mathematics education teachers (Makamure, 2016), whereas Zambian pre-service teachers lacked the relevant mathematical knowledge and the mathematical pedagogical knowledge upon the completion of their training (Changwe, 2017). In addition, a Botswana study reveals that special education student-teachers were not prepared to meet the learning needs of different categories of learners with disabilities in an inclusive setting (Moswela et al., 2009). This suggests that these could have been factors that contributed to inappropriate teaching and eventually poor learner performance in mathematics in schools.

Beliefs about mathematics education. The influence of mathematics teachers' beliefs on teaching practice concerning MLD learners was found only in Namibian studies (Hamukwaya & Haser, 2021; Hamukwaya, 2019). Teachers framed MLD within a deficit framework, thus, seeing learners' difficulties as emanating from cognitive disabilities. Some teachers believe that learners cannot perform, they cannot learn in certain settings or that learners' potential to learn mathematics is limited. Teachers believe students with MLD cannot master the expected skills to perform at a certain level or in a certain learning area, and associate MLD with learners' low interest in mathematics. These beliefs illustrate that teachers are unaware of the causes of MLD.

Conversely, Grade 11 Namibian learners were identified as experiencing MLD by their mathematics teachers. Although these learners did not consider themselves as experiencing LD, they recognized that they were not performing well in mathematics. They believed that they lacked high-level access to teaching and learning, which limited their potential for achieving the level at which they were expected to perform and be academically successful (Hamukwaya, 2020). The learners' perceptions were that their learning processes were negatively affected by systemic factors, as well as teachers and learners' personal factors.

Learners' interest in learning mathematics. Research shows that reasons, such as learners' lack of interest in the subject, unwillingness to learn mathematics and the lack of motivation, contributed to MLD and poor performance (Hamukwaya, 2019). In addition, according to a Botswanan study, learners who did not have an interest in the content taught tended to see mathematics as a waste of time (Mosothwane, 2012).

Lack of parental involvement. Studies conducted in Botswana, Namibia and Zimbabwe found that researchers related poor performance to a lack of parental support caused by parents' educational levels and families' socio-economic status (Baliyan et al., 2012; Mupa & Chinooneka, 2015; Neshila, 2018; Sunzuma, 2018). Learners' failure was related to their life experiences, such as low levels of parental education, low socio-economic status and poverty-stricken families and communities (Neshila, 2018). These situations affected parental involvement in supporting learners' learning negatively (Baliyan et al., 2012).

4. Recommendations and conclusion

The four countries face similar problems and challenges that hinder mathematics teaching and learning, especially for learners with MLD and disabilities. The problem of poor performance in mathematics is one of the concerns of teachers and other mathematics educators. In reviewing the literature, the authors concluded that there was a gap in the literature regarding studies that identify the challenges and provide solutions to MLD in the four developing countries of Sub-Saharan Africa. Consequently, more research on issues specifically related to MLD needs to be conducted.

The review points to a mismatch between policy and practice, negative attitudes, unfavorable learning environment and learning content, among others; these were cited as the major disablers to the success of learners with MLD and other disabilities. This state of affairs could be attributed to system failure and failure to implement responsive policies and calls for the effective and systematic monitoring and evaluation of the implementation of these policies.

Despite challenges in implementing an inclusive education policy in schools, the findings of the review indicate that inclusive education is administered alongside the ordinary school system. Governments ensure that learners, despite their learning disabilities, are included in mainstream classrooms. Findings show that the four countries are still not doing well in implementing an inclusive education system. Hence, a recommendation is made that the necessary capacity building for understanding learners with MLD should be provided to teachers to enable them to offer adequate learning support to these learners.

The review reveals that there appears to be no clear definition of MLD and disabilities, as none of the inclusive education policies mentioned MLD. It is recommended that the Ministry of Education in each country defines MLD to create a common understanding of the concept. This understanding could lead to the correct assessment, intervention and support for learners with MLD. Ideally, this definition should be included in official policies, such as the inclusive education policy and learning support documents. Moreover, there is little evidence of assessment tools to diagnose MLD, except in Botswana. Consequently, it can be argued that placing learners in a classroom without understanding and meeting their needs equates to exclusion within the inclusion. This raises the need for studies about MLD assessment, intervention and learning support in these countries.

The concern of teachers or pre-service teachers' lack of mathematical knowledge and skills and learners' inadequate understanding and comprehension of mathematical concepts are among the contributors to learners' poor performance in mathematics. This, consequently, raises a need for educational programmes to strengthen teachers' continued professional training, as well as pre-service teacher training. Lack of teaching/learning competencies may hinder effective mathematics teaching and cause learners to perform poorly.

The literature acknowledges that the personal beliefs of teachers and learners may influence their teaching practices. Research in all four countries has made recommendations regarding the practical implementation of inclusive education that would benefit the learners and lead to subject-specific challenges, such as MLD. Thus, educational programmes need to reshape those beliefs that may hinder effective mathematics teaching and learning. Recommendations in Hamukwaya and Haser's (2021) study advocate that, during pre-service training, teacher education programmes should focus on increasing teachers' awareness of how their knowledge, practices and beliefs about MLD may influence learners to improve their future practices as teachers.

Although the studies reviewed recommend more learning support, researchers fail to specify its application, especially considering the teacher's workload and the syllabus competencies to be covered. Thus, competency-based curriculum assessment is recommended. Furthermore, it is imperative to develop a curriculum that is inclusive for all learners and supports the individual learners' needs in learning mathematics.

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Improving teaching and learning mathematics in Malawi primary schools: a review of reforms, interventions, successes and challenges

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Abstract

Teaching and learning mathematics in Malawi primary schools has been of concern for many years. This is because of the low learner achievement in national assessments by the Malawi National Examinations Board, where learners' performance in mathematics at end of primary education has been consistently low. In other assessments, such as the Early Grade Mathematics Assessment (Brombacher, 2011) and the numeracy assessment by the Southern and Eastern Africa Consortium for Monitoring Education Quality (SACMEQ, 2011), the average performance of Malawi learners has been below the expectation of the curriculum. In an attempt to address the issues and improve the quality of teaching and learning of mathematics, there have been curriculum reforms which revised the content objective based curriculum to learner outcome based curriculum and aimed at shifting teaching from traditional teacher centred to more learner centred teaching approaches (Ministry of Education, 2007). In addition, over the years there have been interventions in the teaching and learning of mathematics; some interventions targeted mathematics teachers in schools to implement new teaching strategies, while other interventions targeted entire schools and communities. In this paper, we review the reforms and interventions, analyse their successes and challenges, and discuss the implications for improving the teaching and learning mathematics in Malawi primary schools.

1. Introduction

Mathematics is a compulsory subject in Malawi primary and secondary schools. In primary school, mathematics is one of three subjects (the others are English and Chichewa) that is taught every school day. In the first four years (Standards 1 to 4), teaching is in Chichewa or another local language, while from Standard 5 onwards, teaching is in English. Despite the emphasis on mathematics in schools, the learners' achievement continues to be a concern (Brombacher 2019; Ravishanker, 2016). We begin this paper by presenting the problem of learner underachievement in mathematics in Malawi primary schools. Then we give the context by an overview of the Malawi school system and the primary school teacher education. In the rest of the paper, we discuss the reforms and interventions in Malawi that aimed at addressing the problem of primary school learner underachievement. Finally we discuss the implications of theses for improving teaching and learning mathematics in Malawi primary schools.

Primary school mathematics learner achievement

Many studies have revealed that many learners in Malawi achieve below the expectation of the Malawi primary school mathematics curriculum. For instance, the 2008 Primary Achievement Sample Survey for learners in Standard 2 and Standard 7 reported a pass rate of not more than 20%, whereas the 2012 Monitoring Learning Achievement survey reported that 49% of Standard 2 learners, 23% of Standard 4 learners and 59% of Standard 7 learners performed below the expected minimum achievement (Ravishankar et al., 2016). The 2010 Early Grade Mathematics Assessment (EGMA) also revealed poor performance of learners below the expectation of the curriculum (Brombacher, 2011). The EGMS study found that nearly 56% of the 500 participating Standard 2 learners could not perform basic addition of single-digit numbers with a sum of less than 10, which is a curriculum expectation at the end of Standard 1. A more recent Malawi Longitudinal School Survey found that Standard 4 learners scored an average of only 50% for Standard 1 test items and 33% for Standard 4 items (Brombacher, 2019). Similar findings were reported in earlier assessment studies such as the 2006 PCAR Standard 1 Baseline Study, the 2005 study on Monitoring Learner Achievement in Lower Primary School, as well as the 2008 study on Assessing Learner Achievement in Standards 2 and 5 (Maganga et al., 2009).

Internationally, Malawi has participated in large scale assessments by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ), which assess the achievement of Standard 6 level learners. In all the assessments, SACMEQ I in 1995, SACMEQ II in 2000, and SACMEQ III in 2007, Malawi ranked at the bottom as one of two least performing countries in mathematics. The majority of the standard 6 learners were classified as reaching only the lower level competencies of emergent numeracy and basic numeracy, but not the higher competences of mathematically skilled, concrete problem solving and abstract problem solving (Milner et al., 2011).

Brombacher (2019) attributes the much reported learner underachievement in mathematics to the nature of teaching mathematics in Malawi primary schools. He gives the example that even though the number of digits for carrying out addition and subtraction increases as the learners move to the upper classes, the procedure remains the same of single-digit arithmetic that is carried out using counters and the "combine and count all" strategy. Furthermore, the teaching focuses on rote learning and not on understanding, reasoning and application. As such, learners fail to apply their understanding when they face assessment items in a format that is not familiar to them. Other factors that contribute to the low achievements are large class sizes; lack of teaching and learning resources such as text books and exercise books; and problems of learning mathematics in English while not competent in the language (Kazima, 2008, 2014).

The Malawi school system

In Malawi, formal school has eight years of primary and four years of secondary education. The primary school is classified into three sections; infant (Standards 1-2), junior (Standards 3-4) and senior (Standards 5-8). The primary education is free and easily accessible. At the end of primary school, learners sit for the national Primary School Leaving Certificate Examinations, which learners have to pass before admission to secondary schools. Secondary education is not free but the fee is heavily subsidised by the government. The secondary schools are not as easily accessible as primary school. There are many more learners than available space in secondary schools. Learners are selected to national, conventional, or community day secondary schools based on their performance in the national examinations. The secondary education runs for four years, from Form 1 to Form 4. At the end of Form 4, learners sit for the Malawi School Certificate of Education Examinations, which is a national examination used for selection into Universities, teacher education colleges or other institutions.

Malawi primary teacher education

Malawi primary school teacher education is carried out in Teacher Training Colleges (TTCs) for a duration of two years and the qualification obtained in a teacher certificate. As of 2020, Malawi had eight public primary TTCs and eight private TTCs (Ministry of Education, 2020). All the TTCs follow the same curriculum and programme. The teacher education programme prepares generalist teachers such that after completion, the teachers are expected to teach all school subjects and across all classes. There is no specialisation in terms of subjects or level.

The primary teacher education programme in Malawi has gone through changes over the years. Before free primary education was introduced in 1994, the teacher education programme was for three years. In 1994, free primary education was introduced and resulted in huge increase in student enrolment in schools. The three-year teacher education programme was stopped and replaced by the two-year Malawi Integrated In-Service Teacher Education

Programme (MIITEP). This was a crash programme to fast-track training of about 22,000 unqualified teachers who were recruited to address the shortage that was created by an abrupt 51 per cent surge in primary school enrolment (Kunje et al., 2003). MIITEP was on the job training in a blended-mode programme with 4 months of face to face courses at TTCs and 20 months of school-based training in form of teaching practice. MIITEP was discontinued in 2005 after concerns about the quality of the teachers being poor. In 2006, a two-year Initial Primary Teacher Education (IPTE) programme was developed in response to the Primary Curriculum and Assessment Reform (Ministry of Education, 2020). The original IPTE started with one year of college-based courses followed by one year of teaching practice. The programme also had a Distance Learning mode for on-the-job training of unqualified teachers. In 2016, the IPTE programme was reviewed and the structure was revised to start with two terms of college-based taught courses, followed by two terms of teaching practice in schools, and finally another two terms of college-based taught courses, where at the end student teachers sit for their final certification examinations. The distance mode was discontinued and recruitment of unqualified teachers was stopped. Despite the aforementioned changes in teacher education, issues of learner underachievement in mathematics still persist.

2. Review of primary curriculum reform

From content-based to outcome-based curriculum

Prior to 2001, primary schools in Malawi had a content-based curriculum which was first established in 1961 during the colonial era and was continued after independence in 1964 (Ministry of Education, 2019). Although there were curriculum reviews in 1982 and 1991 with the aim of improving the quality of education and to align the curriculum with the social, economic and environmental needs of an independent Malawi (Chirwa & Naidoo, 2014), the curriculum remained content-based. The content-based curriculum was characterised by teacher-centred methodologies where teachers mostly focused on covering the content. In the 1982 curriculum, mathematics was called Arithmetic and emphasised on learners' acquisition of number knowledge and computational skills with speed and accuracy. The curriculum was revised in 1991 following weaknesses that were observed, in particular that it offered too many subjects of study and that it was examination-oriented (Chirwa & Naidoo, 2014; Saka, 2019). The revised curriculum focused on literacy and numeracy. In numeracy, the subject was no longer called Arithmetic but Mathematics, because the subject was meant to develop learners' mathematical capabilities that would help them solve problems in their everyday lives (Malawi Institute of Education, 1991). The curriculum included problem-solving and discovery learning approaches to teaching mathematics. However, it remained a content-based curriculum.

In 2001, another curriculum review started with the main aim of shifting from a content-based to an outcome-based curriculum. The outcome-based curriculum, which is the current curriculum, was designed with a focus on learner achievement; what learners should be able to do at the end of a learning cycle. Two of the key features of an outcome-based curriculum are learner-centred teaching methods and continuous assessment (Chirwa & Naidoo, 2014). In this curriculum, Mathematics has six core-elements which are (i) number operations and relationships; (ii) patterns, functions and algebra; (iii) space and shape; (iv) measurement; (v) data handling and (vi) accounting and business studies. The core element of number operations and relationships takes up to more than 50% of the mathematics time. The expectation of this outcome-based curriculum is that within the first two years, learners should be able to count and perform basic mathematical operations (Ministry of Education, 2004). It is surprising, however, that over a decade from the implementation of the outcome-based curriculum, learners still face difficulties in performing basic mathematical operations such as addition and subtraction (Brombacher, 2019; NSO, 2021), and the problem of learner underachievement persists.

From teacher-centred to learner-centred teaching

Implementation of the outcome-based curriculum started in 2008 through the Primary Curriculum and Assessment Reform (Ministry of Education, 2019). The requirements of this new curriculum called for a major shift from the traditional teacher-centred teaching to learner-centred teaching. This shift involves the use of pedagogical practices that move the focus from the teacher and instruction to the learner and learning (Schuh, 2004). Studies have shown that if well-implemented, a learner-centred approach to teaching and learning promotes active participation among learners and enhances learning (Vavrus et al., 2011). It is now more than a decade since the implementation of the outcome-based curriculum and the associated learner-centred approach. However, success in terms of improving learner performance in mathematics has not yet been registered. Studies that have investigated this reveal that although many teachers are aware of the learner-centred approaches and acknowledge the need to use learner-centred approaches in their lessons, they have challenges with how to use the approaches in their teaching.

Sometimes teachers think they are using learner-centred approaches while in reality they are not (Longwe, 2016; Mizrachi et al., 2010). This implies that teachers have theoretical knowledge about learner-centred teaching, but putting it into practice is a challenge. The second challenge is that teachers perceive learner-centred approaches as too involving and time-consuming during both lesson preparation and delivery (Chiphiko & Shawa, 2014). The third challenge is large class sizes, which make facilitation of meaningful learner participation difficult (Chiphiko & Shawa, 2014; Mtika & Gates, 2010). In Malawi, it is common to have classes of more than 100 learners against one teacher (Brombacher, 2011). As Mtika and Gates (2010) argue, the implementation of learner-centred teaching approaches works well in classes with a reasonable number of learners because teachers can easily manage to provide individual support. The challenges faced in the implementation of learner-centred approaches tend to force teachers to revert to the use of teacher-centred approaches (Chiphiko & Shawa, 2014), and this might explain why learners still

continue to perform below the expected achievement level in Mathematics. The concern in mathematics achievement has led to a number of interventions, which we discuss in the next section.

3. Review of interventions

Large scale and long term interventions

The Numeracy Boost intervention

The Numeracy Boost intervention started in 2012 with support from Save the Children. It was introduced in selected rural schools in one district. The initiative was motivated by the low achievement of Malawian learners in mathematics in comparison to that of learners from other countries in the region (Milner et al., 2011) and early years' learner performance that is below Malawian curriculum benchmarks (Brombacher, 2011). The Numeracy Boost intervention has three components: community camps, capacity building and learner assessment.

Community camps

Numeracy camps are the core feature of the Numeracy Boost intervention. The camps are placed in communities surrounding intervention schools, and operate after school in a non-structured play-like environment. They are run by camp facilitators who are volunteers from the communities. The camp facilitators are coordinated by qualified school teachers, termed camp supervisors, and they act as a link between the community and the school. The camp supervisor suggests focus areas of mathematics content for a specific period based on coverage of mathematics in school (Mbendera, 2019).

Capacity building

The Numeracy Boost intervention provides short training to volunteer camp facilitators and teacher camp supervisors. The intervention also provided training for mathematics teacher educators at primary teacher training colleges, and these were involved in developing teaching and learning materials for the camp, as well as training the camp facilitators and supervisors (Mbendera, 2019).

Learner assessment

The Numeracy Boost intervention has three content focus areas: (i) number concepts and operations, (ii) geometry and (iii) measurement, which are considered universal conceptual areas that are taught to learners during the early years of primary school. Thus, the initiative deals with topics such as counting and place value, addition and subtraction, shape identification and composition, and understanding units and tools of measurement. In the communities where the Numeracy Boost initiative is implemented, each academic year begins with a baseline diagnostic assessment and ends with an end-line assessment and report. The baseline assessment is used to identify learning gaps in the focus areas, hence informs the structuring of the interventions during the academic year. The assessment is also offered to control schools for comparison (Mbendera, 2019).

Successes of the intervention include that it provides a structure in which the community is positively involved in their children's learning of mathematics. This has led the learners and communities to develop a positive attitude towards mathematics (Save the Children, 2018). Another success is that learners have another site of learning mathematics. Some teachers utilise the numeracy camps for complementing work not thoroughly covered in the classroom. Training of teachers as camp supervisors offers teachers the skills and knowledge of operating mathematics camps and interacting with the community and discussing mathematics informally.

However, the intervention also faces some challenges: firstly, the volunteer camp facilitators lack support from camp supervisors (Mbendera, 2019), probably because the camp supervisors are teachers with busy workloads and do not have much time for the camps. Secondly, the running of the camps depends on the availability of volunteer facilitators and some camps do not take place as often as desired, which is twice a week. Thirdly, there are no permanent meeting structures, such that the numeracy camps are often conducted at open spaces prone to environmental conditions such as rain. Finally, some consider the meeting times of twice a week inadequate to address the learning gaps among the children (Mbendera, 2019).

The Unlocking Talent project

The Unlocking Talent (UT) through Technology is an international project aimed at improving numeracy and literacy for marginalised early years learners worldwide (Pitchford, 2018). This project uses tablets to deliver learning instructions to learners in the early years of primary school. The tablets are loaded with learner-centred apps that are developed based on the primary school curriculum content of the country in which they are used (Pitchford, 2018).

In Malawi, the UT project is funded by the Norwegian Embassy and implemented in partnership with the Voluntary Services Oversees, the Malawi Ministry of Education, Onebillion, DFID, UNICEF and the Scottish Government (Royal Norwegian Embassy, 2017). The project was introduced in Malawi to address the continued reports and concerns about the low level of primary school learners' attainment in mathematics, which were reported by the different assessment studies discussed earlier. Key factors that were attributed to this problem of learner underachievement include lack of textbooks and other teaching and learning resources; overcrowding in classrooms and the quality of teaching. In order to overcome these challenges, the UT was created as an intervention focused on basic numeracy skills, without relying heavily on the quality of teachers (Hubber et al., 2016).

Implementation of the first phase of the UT project was launched in 2014 and the second phase was launched in 2018. The project is being implemented in more than one hundred primary schools throughout the country, targeting early years learners. Each of these participating schools gets equipped with about 30 tablets preloaded with Onebillion apps. Each school has a purpose-built learning centre within the school campus, where the intervention takes place (Pitchford et al., 2019). During the school hours, 29 learners at a time are pulled out of their regular classes to use the tablets in the learning centre. The learners learn mathematics individually using the apps loaded into the tablets. The app has sound and each tablet is connected to a headphone so that each learner focuses on his or her own activities without being distracted by noise from the others. All the apps are in Chichewa, which is the national language of Malawi. The tablets are designed in a way that they are easy for the learners to use, and the learning centre teacher acts only as a facilitator. The teacher registers the learners on the tablets, monitors learners' progress and solves technical problems. The app gives feedback to the learner as they work through the mathematical activities (Pitchford et al., 2019).

The UT intervention has registered some successes towards the learning of mathematics in the early years of primary school. In a randomised study conducted by Pitchford (2015), it was revealed that the intervention helps to support learners' development of early numeracy skills. One of the reasons for the success is that the interactive features of the apps enable learners to progress through the mathematics content at their own pace, and it allows learners to repeat activities when needed (Outhwaite et al., 2017). Another success story from this intervention is that it promotes inclusivity in terms of gender and special education needs (Pitchford, 2019). The UT intervention has been observed to be an effective way of equalising learning opportunities for both boys and girls, thus helping to narrow the gender gap that exists in mathematics attainment between girls and boys in primary schools, in favour of boys. Furthermore, positive impacts and learning gains have also been registered on learners with some special educational needs (Pitchford et al., 2018). However, learners with hearing impairment made slow progress through the apps compared to their peers because the apps use verbal instructions, and this limits their ability to learn (Pitchford, 2019).

There are some challenges that the UT intervention faces. These include that it does not include learners with hearing impairments. Another challenge is that the intervention is implemented in only about one hundred schools countrywide (Pitchford et al., 2019), out of more than five thousand. Therefore, it reaches only a small proportion of the primary school learners in Malawi. Finally, pulling learners out of their regular classes to use the tablets does not seem to be a good strategy because the learners miss other lessons while attending the UT sessions.

Small scale and short term interventions

Improving the quality and capacity of mathematics teacher education in Malawi

A collaboration between the University of Malawi and the University of Stavanger, Norway, led to a five-year project from 2014 to 2018. The overall goal was to improve mathematics education in schools through improving the quality of teachers. The project focused on enhancing the capacity of mathematics teacher education. A professional development programme was developed by the project and offered to all mathematics teacher educators in all public primary teacher education colleges. The project was funded by the Norwegian Agency for Development Cooperation (NORAD) through the Norwegian Programme for Capacity Building in Higher Education and Research for Development (NORHED). The project worked with two or three teacher colleges each year and offered the professional development programme to all mathematics teacher educators at the colleges. The programme started with a three-day workshop, followed by lesson study activities in the colleges, then ended with another three-day workshop (Kazima & Jakobsen, 2019).

The success of the project is that it reached all eight public primary teacher colleges and enhanced the teacher educators' capacity to offer improved quality mathematics teacher education courses in their colleges. It thus improved the quality of teachers they prepare. Another success was the creation of networks across the colleges which was facilitated by the mathematics teacher educators from different colleges meeting and working together during the professional development workshops. The networks have continued after the project and continued to promote good quality mathematics teacher education. A challenge for the project was that during the lesson study activities in the colleges, the professional development facilitators worked with the mathematics teacher educators remotely through emails. A study on the professional development established that more support by physically visiting the colleges might have been more effective (Fauskanger et al., 2020).

Strengthening numeracy in the early years of primary education through professional development of teachers project

This is an ongoing five-year collaborative project between the University of Malawi and the University of Stavanger running from 2017 to 2022. The project aims to improve the teaching and learning of numeracy in the first four years of primary school and is also funded by NORAD through NORHED. The target is rural schools which are the most disadvantaged in Malawi (Kazima & Jakobsen, 2019). The project offers professional development to teachers of standards 1-4. The duration is seven months; it starts with a three-day workshop which covers counting, early number concepts, and an introduction to lesson study. This is followed by lesson study in schools with the support of the project team. It ends with another three-day workshop where the lesson study is reflected upon and further plans are made. The second workshop also covers the mathematics teaching

framework (Adler & Ronda, 2015) and more number concepts (Kazima & Jakobsen, 2021).

The success of the project includes that it has enhanced the teachers' capacity in teaching mathematics in the early years. Through the lesson study, the teachers have developed their skills in reflecting on their teaching and working together to improve their mathematics teaching. Challenges are that in many rural schools there are large classes of more than 100 learners to one teacher, and lesson study in such large classes can be challenging. Conducting lesson study is time consuming and it takes time for teachers to see the benefits of working together within the schools. The project is relatively small and reaches only a small proportion of the rural schools.

JICA Numeracy project

This intervention was carried out in 2016 to help learners progress from unit counting to composition and decomposition – for example, to be able to recognise 7 + 5 as (7 + 3) + 2 and obtain the answer, 12. The intervention involved three weeks of training for Standard 1 to 3 teachers from two pilot schools. A pre-test was administered to a sample of 21 Standard 2 learners and 21 Standard 3 learners who were observed doing unit counting with their fingers. This was followed by the intervention of teaching the learners using patterns of composition and decomposition, then a post-test. It was observed that the learners were able to work out the problems without unit counting during the post-test, suggesting that they were able to progress to composition and decomposition strategies of addition and subtraction.

4. Discussion

The reforms and interventions were developed and implemented to address the concerns of low achievement in primary school mathematics as revealed by the various assessments discussed earlier. The goal is to improve the teaching and learning of mathematics in schools and consequently improve learner achievement. Each of the reforms and interventions contributes to this common goal. The curriculum reform was for the whole school curriculum and therefore was a more general approach. The shift from content-based to outcome-based curriculum was aimed at focusing on the desired outcomes in terms of learning rather than focusing on content in terms of teaching. Thus, learner-centred teaching was emphasised to achieve the desired outcomes. The reform was a good move because the benefits of learner-centred teaching over teacher-centred teaching in mathematics are well documented (Ganyaupfu, 2013; InWent, 2009). The question that arises is why then has the reform not succeeded in resolving the problem of low achievement in mathematics? Research has shown that the success of learner-centred teaching is compromised because the shift was not supported by the relevant conditions of reduced class size, learner-centred textbooks, and teacher support. Another important factor is the schools' focus on national examinations which lead to examination-oriented teaching. The national examinations are high stake because good performance secures space in the highly competitive secondary school admission. Therefore, it is not surprising that schools focus on passing the examinations and not necessarily understanding.

The two examples of large-scale interventions also contribute to the common goal of improving learners' learning and achievement. They both aim to support learners in their learning of mathematics. The Numeracy Boost focuses on the community and relies on volunteers and children attending the camps outside school hours. The benefit of involving the community is that the children are supported in their learning by their community and the children, as well as the community developing a positive attitude towards mathematics. A positive attitude toward mathematics leads to a productive disposition which is an important strand in becoming proficient in mathematics (Kilpatrick et al., 2001). This intervention is possible to scale up to other schools because it has minimal costs; the costs are only in terms of the training of the volunteer camp facilitators, and the teacher camp supervisors. However, there is a need for evaluation so that the benefits and strengths are retained and the weaknesses are addressed, for example enhancing the capacity of the volunteers by strengthening their training and support.

The Unlocking Talent intervention focuses on the individual learners during school hours and it relies on teachers. The app on the tablets enables learners to learn and progress through the activities at their own pace. Thus, it offers the benefit of experiencing individual learning that is not reliant on others. Such learning enhances learners' confidence and a positive attitude towards mathematics, thus contributing to their development of productive disposition (Kilpatrick et al., 2001) in mathematics. This intervention has registered successes in improving learners' achievement in mathematics and has shown to be effective in inclusiveness. The evaluation of learners within the intervention has shown that individual learning using tablets reduces inequalities among boys and girls, and learners with special educational needs. Although this is clearly a desired outcome for Malawi, scaling up the intervention is not realistic because of the costs, and is not sustainable after the intervention project life. In the intervention schools, they have only 30 tablets against hundreds of children, such that learners take turns to use the tablets during school hours. While using the apps is proving beneficial to the learners, the consequences of missing other lessons should not be underestimated. It might have been better to have the tablet time outside the school hours, although that would have its own challenges, such as the need for additional teachers' time.

The small scale interventions also have the same common goal of improving learning and achievement in school mathematics. The focus is different for each; the first NORHED project focused on mathematics teacher educators, the second on teachers, and the JICA project focused on learners. The focus on teacher education was good because it recognises that teacher education and in particular mathematics teacher educators play a big role in mathematics teaching and learning in schools. Therefore, enhancing the capacity and quality of the teacher educators enhances the quality of mathematics teacher education and

the teachers produced. The project already scaled up to all public teacher colleges in the country. It is possible to sustain the lesson study in the teacher colleges and continue to improve the mathematics teacher education in the colleges and hence the quality of mathematics teachers produced. However, this is more of a long-term solution and therefore the need for other more immediate solutions.

The second NORHED project which focuses on teachers is one such more immediate solution. An evaluation within the project has shown that teachers find the professional development activities useful; it enhances their capacity to reflect on their teaching and pay attention to their learners' learning (Kazima & Jakobsen, 2021). This intervention is possible to scale up and sustain because the project uses existing government structures of schools, zones and districts which will continue to operate after project life instead of introducing project structures which end with the project. However, there might be challenges in terms of the costs of offering the workshops to teachers and having enough competent personnel to facilitate the workshops and support the teachers in the lesson study in schools.

The small-scale JICA intervention focused on learners in schools and one specific strategy for addition and subtraction. Teachers were involved and offered training on how to teach the strategy to learners. The intervention contributes to the common goal of improving the learning of mathematics because it demonstrates that the strategy works, and learners are able to progress from the counting all strategy to more mathematically efficient strategies. This intervention is possible to scale up. However, since it is only one strategy, it might not be economical to scale up on its own. It would be more cost effective to have it as one of many other strategies for various operations offered as professional development of mathematics teachers.

5. Conclusion

In this paper, we have presented the persistent problem of primary school learner underachievement in mathematics in Malawi, as registered by both national and international assessments, and we have reviewed the reforms and interventions aimed at addressing this low achievement. From the review and discussion, it can be seen that improving the teaching and learning of mathematics involves many stakeholders, including teachers, learners, teacher educators, schools, and the community. All of these play a part in developing the learners' interest in, and learning of mathematics. While it might not be possible for one intervention to focus on all these, being mindful of the roles the other stakeholders play can make a difference. There have been successes and challenges for all the interventions. It is important to draw from the successes to move forward and also learn from the challenges. It is also important to recognise the strengths of the teachers in Malawi. For example, they have skills of teaching in large classes, teaching with limited resources, and the skill of making their own teaching and learning aids from locally available materials. In most cases, teachers are enthusiastic to teach mathematics and learn through professional development. Making the most of these strengths would strengthen the teaching and learning of mathematics and have a positive impact on learner achievement. Although it is not practical to scale up and sustain some of the interventions, they reveal what is possible to achieve and can guide the conceptualisation of more realistic interventions that can be implemented and scaled up. The small-scale interventions also inform what is possible and can form a basis for larger-scale interventions. The interventions targeting learners have shown that learners in Malawi have the ability and potential for high achievement in mathematics. It is therefore important to find ways of addressing all the factors that limit learners' achievement and continue working towards effective teaching and learning of mathematics in Malawi schools.

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