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Country-Level Research Review: EdTech in Kenya

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Notes

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Contents page

Abbreviations and acronyms

CSO	Civil Society Organisation
GEC	Girls' Education Challenge
GPE	Global Partnership for Education
HALI	Health And Literacy Intervention
ICT	Information and Communication Technology
INS	Instant Network Schools
LMIC	Low- and middle-income country
LCBEP	Learning Continuity in Basic Education Project
MoE	Ministry of Education
MoICT	Ministry of Information and Communication Technology
MoEST	Ministry of Education, Science and Technology
MOOC	Massive Online Open Course
NACOSTI	National Commission For Science, Technology & Innovation
NEMIS	National Education Management Information System
NGO	Non-governmental organisation
ODA	Official development assistance
PEA	Political economy analysis
RLI	Research landscape index
SAGA	Semi-autonomous and autonomous government agency
SIDA	Swedish International Development Cooperation Agency
ST&I	Science, Technology and Innovation
TESSA	Teacher Education in Sub-Saharan Africa
TPD	Teacher professional development
TSC	Teachers Service Commission

Executive summary

This document presents a review of the research landscape in Kenya in relation to EdTech research focused at the level of school-based education (not including higher education). The search strategy identified research literature, policy documents, grey literature, and communications with key experts and stakeholders. A growing body of relevant EdTech research is identified to have been undertaken in Kenya. After undertaking searches for relevant literature since 2007, 87 research articles or papers were identified for inclusion. The review provides an overview of trends in this literature in addition to identifying key actors and projects. It also considers how existing research on EdTech in Kenya relates to five research topics that will be the focus of future EdTech Hub research. In combination with political economy analysis, the research identifies potential areas for new research which would be practical and likely to have high impact.

1. Introduction

This review provides an overview of EdTech research in and about Kenya. It does so in order to identify the opportunities for further EdTech-related research in the country and to understand how EdTech Hub can collaborate with researchers, practitioners, and policymakers most effectively. The report will be important for researchers in Kenya and the surrounding region, as well as for EdTech implementers seeking to understand what evidence exists and what is needed. Through analysis of existing literature, discussions with key stakeholders and experts, and analysis of the broader political economy, the gaps in evidence that have the highest potential for impact on education are identified to inform future research priorities. These priorities will also serve to foster and sustain conversation within a community of practice and learning shared by education stakeholders.

1.1. Structure

The review is made up of seven sections:

1. Introduction
2. Summary of the EdTech operating context
3. The texture of the EdTech research landscape
4. Key stakeholders within the EdTech research landscape
5. Summary of the academic evidence on EdTech
6. Summary of political economy analysis
7. Emerging priorities and opportunities for collaboration

1.2. Methodology

To address the aims of the review, a combination of approaches were used in order to draw upon a range of sources.

Analysis of background demographic statistics and policy documents informed the context (Section 2), and political economy analysis (Section 6). Section 2, in particular, drew upon previous work undertaken by the Engagement team within EdTech Hub (↑Otieno & Taddese, 2020).

A review of published academic research literature was undertaken to provide an overview of the existing research landscape around EdTech and education for school-aged learners in Kenya (Section 3). This provides an overview of trends — and current gaps — in addition to identifying key actors and projects. It also considers how existing research on EdTech in Kenya relates to the five research topics that will be the focus of EdTech Hub's research (Section 5). The research review also provided a way of exploring key academic stakeholders related to EdTech in Kenya (Section 4). The volume of EdTech-related research in Kenya has been increasing in recent years and 87 academic publications were identified for inclusion. The search process and its limitations are described in Section 3.

Interviews with stakeholders informed several aspects of the report, in particular the political economy analysis (Section 6). Situating the priority research areas within the political economy analysis also brings a practical dimension. Potential directions for high impact research in Kenya, aligned with the priorities within the country and with those identified by the Hub, are outlined in Section 7. Each section starts with an overview of the data sources used.

2. Summary of the education operating context

This section provides an overview of Kenya's education sector operating context. The section begins with a brief overview of national contextual factors which influence the delivery of education in Kenya. This is followed by a brief review of primary and secondary education service delivery. The section finishes with a description of education service delivery since the onset of the Covid-19 pandemic. By providing an understanding of the education sector more broadly, this section helps position the insights into the EdTech research base presented in subsequent sections.

2.1. Country context

Kenya is home to a population of approximately 52.6 million people living across a diverse range of contexts (↑World Bank, 2021). These include the metropolis of Nairobi, the long eastern coastline bordering the pacific ocean, the fertile lands of the great rift valley, the deserts of northern Kenya, and the savannah of the Maasai Mara. The national language is Kiswahili, but there are two official languages: Kiswahili and English.

Kenya's population is young and is growing quickly. Approximately 39.1% of citizens are aged between 0–14, there is a median age of 19.7 years (half that of the US and China) and the population growth rate is 2.3% per year (↑World Bank, 2021; ↑World Bank, 2021; ↑World Bank, 2021).

Kenya is often viewed as a leader and an exemplar of good development practices within the eastern and southern regions of Africa. As of 2020, Kenya had a Human Development Index value of .602, placing it 143rd out of 189 countries and within the medium category on the Human Development Index (↑United Nations Development Programme, 2021). This contrasts with neighbouring countries such as Uganda (index of .544 and ranking of 159), Rwanda (.543 and ranking of 160) and Nigeria (.539 and ranking of 163). Kenya's 2020 standing is an improvement from 2019, when its value was 0.579, placing it 147th of 189 nations.

Despite good development progress, the country experiences significant levels of disparity. For example, income inequality is extreme. The top 0.1% of Kenyans possess more wealth than the bottom 99.9% (↑Otieno & Taddese, 2020). This inequality often manifests along geographic lines. For example, of the 14.5 million people living in urban areas (27.5% of the population), 84% have access to electricity. This contrasts with only 71% in rural areas. Table 1 includes

an overview of key indicators that provide insight into Kenya's general development.

Table 1. *Country overview. Source: Adapted from ↑Ministry of Education, Republic of Kenya, 2018; ↑United Nations Development Programme, 2020, ↑Otieno & Taddese, 2020; ↑Kaye, 2021; and The World Population Dashboard.*

Population indicators	Total population (2021)	The population is 55 million. The growth rate is 2.3% per year.
	Age (2021)	59.4% of the population is aged 15–64 38.0% of the population is aged 0–14 Median age: 19.7 years
	Urban / Rural divide	Percentage of urban population: 27.0% Percentage of rural population: 73.0%
Development indicators	Human development index	0.601
	Life expectancy	66.7 years
	Fertility rate	3.79 births per woman
	Poverty	Percentage of population living in poverty: 36.8%
Digital indicators	Mobile phones (2020)	Mobile penetration: 98% Mobile connections: 52%
	Internet (2020)	Internet penetration: 43%

NB — Figures are from 2019 unless otherwise stated

2.2. Education in Kenya

In the lead-up to the new millennium learning in Kenya had stagnated. Access was low, with primary net enrolment only just over 60% in 1999 (↑World Bank, 2021). Learning outcomes for those children in school also remained well below international averages. Noting these challenges, the Kenya government embarked on two phases of ambitious education reforms — first focusing on access and then on improving education quality. These reforms are part of the government's ongoing commitment to build a high-quality education system that meets the needs of its citizens and the state, while also acknowledging the complex socio-economic, political, and cultural dynamics. The reforms also provide a foundation for Kenya to make the most of a potential demographic dividend, which will emerge over the coming years. It is estimated that by 2050 Kenya's working-age population will be 73%, which has the potential to

boost GDP per capita to 12 times the current rate of circa 90% of the population are formally employed (↑Kibaru-Mbae & Chatterjee, 2016).

In 2003, free primary education was introduced nationally, and was shortly thereafter, in 2008, followed by free secondary education (↑Kaye, 2021). These reforms, designed to increase access to education, have led to universal primary enrolment. Gross enrolment in secondary education increased to above 70% in 2018 (↑Otieno & Taddese, 2020). These reforms also tried to increase equity across genders. Again, this has been successful, with the gender parity index reaching 0.97 (97 girls enrolled for every 100 boys) in primary and 0.95 in secondary (↑Otieno & Taddese, 2020).

As enrolment rates have increased, the focus of reform has shifted to increasing education quality. Since circa 2013 the government has deployed a number of reforms aimed at enhancing education quality. Examples include developing a competency-based curriculum, more support for teacher development, and a move to enhance community engagement by creating localised school boards of management. These reforms have already begun to lead to increases in education outcomes reflected in regional testing results (↑Kaye, 2021).

2.2.1. Education system governance

Oversight and governance of Kenya's general education system (i.e., primary and secondary) is the responsibility of the Ministry of Education, Science and Technology (MoEST). The MoEST is mandated by the constitution of Kenya to provide quality and affordable education to all Kenyan children (↑Otieno & Taddese, 2020). The MoEST's Department of Early Learning and Basic Education is responsible for defining and delivering policies and programs for primary and secondary education.

In addition to the MoEST, semi-autonomous and autonomous government agencies (SAGAs) play key roles in education delivery. These SAGAs, which include the Teacher Service Commission, the Kenyan Institute of Curriculum Development and the Kenya National Examination Council among others, play important roles related to discrete areas of education service provision.

A recent devolution of power to local governments has shifted the nature of education management and governance in Kenya. In 2010 a new constitution was introduced that empowered Kenya's 47 counties to play a greater role in public service delivery. This includes the oversight of education provision. This change resulted in the creation of county and sub-county offices in each municipality with the idea that this would ensure that the MoEST was able to better engage with local groups and better meet local needs. This shift altered

lines of accountability for service delivery and quality, with county-level officers now conducting quality assurance, inspection, and teacher training.

Finally, Kenya's education system governance is made more complex by the substantive roles played by actors such as development partners, non-governmental organisations (NGOs), and the private sector. In Kenya, official development assistance (ODA) received from aid organisations is significant, with ODA comprising 6% of Kenya's gross national income (↑World Bank, 2015). Non-state actors play important roles in the delivery of education more broadly, but also the implementation of interventions that leverage EdTech specifically. For example, non-governmental actors as diverse as Safaricom (the national telecommunications provider), the World Bank and the Keep Kenya Learning campaign (a collaboration of both private and NGO education providers) support education delivery.

2.2.2. Education system characteristics

Kenya's general education system comprises three main phases. These are:

- Early childhood development and education — Ages 3–5.
- Primary education — Ages 6–13
- Secondary education — Ages 14–17

In addition to these phases, the system also comprises both formal and non-formal opportunities for vocational and technical training (generally available from approximately age 10 and up).

Table 2 contains key education service delivery indicators.

Table 2. *Key education service delivery indicators (2016–17). Source: Adapted from ↑Otieno & Taddese, 2020; ↑Ministry of Education, Republic of Kenya, 2018; ↑Ministry of Education, Republic of Kenya, 2019.*

Pre-primary	Learners	Total: 3.39 million Females: 1.66 million Males: 1.73 million Net enrolment: 77.2%
	Institutions	42,317
	Teachers	Total: 92,359 Public: 52,780 Private: 39,579

Primary	Learners	Total: 10.54 million Females: 5.18 million Males: 5.36 million Net enrolment: 92.4%
	Institutions	Total: 37,910 Public: 24,241 Private: 13,669
	Teachers	Total: 350,532 Public: 218,760 Private: 68,772
	Completion	Primary completion rate: 84.2%
Secondary	Learners	Total: 2.94 million Females: 1.44 million Males: 1.51 million Net enrolment: 53.2%
	Teachers	Total: 350,532 Public: 218,760 Private: 68,772
	Teachers	Total: 116,910 Public: 105,234 Private: 11,676

It is important to expand upon and explicitly highlight some of the indicators contained in Table 2. These include:

1. As mentioned above, enrolment rates have increased considerably over the last two decades. While these rates have increased, there are still significant drop-offs. These generally occur at education transition points (e.g., from primary to secondary or secondary to tertiary) (↑Otieno & Taddese, 2020). Child labour continues to impact education participation and the ability to achieve high learning outcomes. Approximately two-thirds of children aged 5 to 11 work at least an hour a week for payment. More than 10% of children aged 12 to 14 work more than 14 hours per week (↑Kaye, 2021).

2. The macro-level figures shared throughout this section conceal significant educational disparities between different regions in Kenya. For example, enrolment varies substantially across counties. Low rates

are particularly prevalent in arid and semi-arid counties (↑Otieno & Taddese, 2020). The majority of the 1.1 million Kenyan children estimated to be out of school are from these counties. Other areas of significant disparity include coastal areas and urban slums (↑World Bank, 2015).

3. The quality of teaching in Kenya remains low by international standards. There is a lack of qualified teachers to staff schools, and where teachers are in place, capacity is often low. It is estimated that there is a shortage of nearly 100,000 teachers, and this is expected to continue to increase over time (↑Otieno & Taddese, 2020). Even where teachers are employed, a recent survey found that 16% are absent from school, and 29% were in school but not teaching (↑World Bank, 2015).

4. Supporting children with special needs remains a significant challenge in Kenya. Only 39% of students with disabilities access primary education, and only 9% access secondary (↑Angoye, et al., 2020). This lack of inclusion is linked to deficits in infrastructure, a lack of relevant equipment, a lack of training for teachers on how to meet learner needs, and societal limitations.

2.2.3. Reform priorities

Kenya's National Education Sector Strategic Plan sets out the reform priorities for Kenya between 2018 and 2022 (↑Ministry of Education, Republic of Kenya, 2018). These are to:

- Enhance access and equity;
- Provide quality and competency-based education, training, and research;
- Strengthen management, governance, and accountability;
- Enhance relevance and capacities for Science, Technology and Innovation(ST&I) in education, training, and research for labour markets.

This reflects the Kenyan government's public commitment to strengthen and deepen the reforms that have already been in progress for some years now, with a real focus on increasing education quality. The focus on ST&I also reflects the Kenyan government's aim to develop a workforce that is equipped to drive national prosperity in the 21st century. This aligns with the plans and policies of other government agencies such as the National Information, Communications and Technology Policy, which articulates the aim to:

- Integrate Information and Communications Technology(ICT) at all levels of education;

- Create a nationwide e-Education system to support schools;
- Retrain and reskill the current workforce on ICT;
- Establish educational networks for sharing resources and promoting e-learning;
- Facilitate public-private partnerships to mobilise resources for e-learning initiatives.

This kind of alignment between policy and reform priorities indicates that the shift to position Kenya to be a leader in relation to the adoption of digital technology goes beyond just the education sector and is integrated into ambitions and reforms across the country as a whole.

2.3. Impact of Covid-19

Like most countries, Kenya's education has been significantly impacted by Covid-19. Approximately 17 million learners across the country had their learning disrupted by school closures (↑Jelimo, 2020). The first Covid-19 case was recorded in Kenya on 13 March 2020, with the government announcing schools would close on 15 March 2020.

The government moved quickly to deploy a range of solutions to support learning continuity while schools were closed. Multiple modalities, including television, radio, and internet, were all leveraged to deliver content to students at home. The Kenya Basic Education Covid-19 Emergency Response Plan was launched in May 2020 to try to ensure the various modalities were being implemented as a cohesive, integrated package (↑Ministry of Education, Republic of Kenya, 2020). The plan aims to:

- Provide learners with access to quality and equitable education to ensure continued learning during and after the Covid-19 crisis;
- Facilitate the production of online teaching and learning materials, and expand existing distance learning provisions;
- Train teachers to effectively support distance learning, including monitoring and assessment;
- Develop and implement intervention programmes targeting the marginalised and most vulnerable learners, especially girls and children with special needs;
- Provide psychosocial support to learners, teachers, education officials, and other stakeholders.

The plan integrates activities designed to support a coordinated approach to providing students with learning continuity. This includes creating additional content (text, audio, video, interactive, etc.) that can be accessed via various modalities (TV, radio, internet, etc.). It also includes strengthening existing mechanisms designed to support distance learning, such as the Kenya Education Cloud, and procuring new and better equipment to create digital content. Importantly, the plan also includes a focus on increasing teacher capacity to support students to make the most of distance learning tools.

This plan has received funding from the Global Partnership of Education to support implementation through the Learning Continuity in Basic Education Project (LCBEP). The latest implementation status report (March 2021) indicates that implementation of the LCBEP is considered satisfactory (↑World Bank, 2021). The report highlights that considerable proportions of students are accessing the various educational modalities. This includes 69.29% of learners accessing EDu TV programming, 42.26% accessing radio lessons, 22.09% accessing content on YouTube, and 17.02% accessing the Kenya Education Cloud.

This high level of uptake was driven through various project initiatives, including the creation of nearly 2,500 interactive lessons that are accessible via TV, radio, internet, and social media. Approximately 250 tips have also been created and shared with parents to support them to guide children to learn at home. Training for teachers is developed and is expected to reach 150,000 teachers by April 30 2021. This work has been particularly important due to the ongoing closure of Kenyan schools. While schools were re-opened in January 2021, as of April 2021 they have been closed again following another increase in Covid-19 cases.

Finally, it is important to note that the government's focus has gone beyond simply responding to the Covid-19 crisis. Strategies and implementation plans all highlight an awareness of the fact that the shocks felt in the short term have the potential to be ongoing, and that a robust response to the current closures will lay the foundations for resilience in the face of future shocks.

3. The texture of the research landscape on EdTech

This section provides an overview of the existing research landscape in relation to EdTech in Kenya. EdTech research has been actively undertaken in Kenya and the Kenyan EdTech ecosystem was described as one "of the most vibrant in Africa" by ↑Otieno & Taddese (2020, p. 17). Consequently, there is an existing body of EdTech research on which EdTech Hub can build. The characteristics of this research will be illustrated in this section. This analysis of the literature will also inform the introduction of authors and major projects related to EdTech in Kenya in Section 4.

A strategic approach was adopted to search for published EdTech research literature. Given that 'EdTech' is an umbrella term, which encompasses a wide range of subjacent terms, approaches, and technologies, searches were conducted with a primary focus on 'Kenya'. The search strategy included four steps (undertaken in the following order):

1. Initial searching of key EdTech research documents for Kenya-focused studies. This included existing reviews of EdTech studies in low- and middle-income countries (LMICs) (for example, ↑Rodriguez-Segura (2020), evidence reviews, and EdTech Hub publications (for instance, ↑Otieno & Taddese (2020) and ↑Haßler et al., (2020)).

2. Searching specialist education research databases (ESSA, Academia.edu, ResearchGate) for all Kenya-focused studies and selecting those which met the inclusion criteria (published since 2010, being EdTech-related, and focused on school-aged learners, teachers, or aspects of the educational system relevant to school-aged learners).

3. Searching general academic databases (Scopus, Google Scholar) for 'Kenya' and a range of general EdTech terms listed in Annex A (such as educational technology, e-learning, technology-enhanced learning, Massive Open Online Course (MOOCs), ICT, mobile learning).

4. Snowballing searches for further articles from authors identified as prominent in the literature, in addition to generic search engine searches to identify further potentially relevant information or 'grey literature'.

While it is not possible to guarantee that the search results are exhaustive given the wide range of technologies and approaches that can be considered 'EdTech', a level of saturation was considered to have been reached when

implementing the search strategy as continued searches did not produce further results meeting the criteria. Thus, although this approach stops short of being a 'full' systematic review (not least because it was undertaken in a relatively short period of time), the sample is considered to offer an accurate representation of the EdTech research literature focused on school-aged learners, teachers, or aspects of the educational system relevant to school-aged learners in Kenya.

Articles identified through the search process were read in full, and information about those which met the search criteria was entered into a spreadsheet, mapping their characteristics to a pre-defined 'research landscape index' (RLI) framework. Eighty-seven articles, written by 150 unique authors, were entered into the RLI (accessible here). Categories within the RLI included: bibliographic information; authors; institutions; funders; research methods; sample size; study topic; and relevant Hub thematic area (each presented as subsections in Section 5).

Of the 87 articles selected for this review, 76 are academic papers and 11 fell within the grey literature. The majority of the EdTech literature in Kenya is based on empirical research (60%) followed by exploratory research. Only four theoretical studies were found through our literature search strategy. There is an almost equal distribution of literature focusing on learners, teachers, and systems in the context of EdTech in Kenya.

With respect to study sizes, the literature includes studies that cover a range of stakeholders within the EdTech ecosystem, with several studies featuring more than one stakeholder. The literature also includes a wide range of sample sizes, with some studies including over 3000 participants and others as low as three, as shown in Table 3 below. Box plots of sample sizes are shown in Figure 1 (a minimum threshold for the number of studies with a specific participant was set at 5 for the box plot). Research methods in the Kenyan EdTech literature varied across studies with surveys and questionnaires contributing to over 40% of the studies, followed by content and thematic analysis and mixed-methods approaches, these are illustrated in Figure 2.

Table 3: *Overview of sample sizes in the articles included in the Kenya literature review.*

Stakeholder/participant	Obs	Mean	Std.Dev.	Min	Max
Teachers	36	117.5	216.3	3	1100
Students	21	524.3	707.4	5	3030
Schools	20	33.15	35.52	2	105
Principals	5	12.8	5.891	8	23
Headteachers	3	150.7	163.1	40	338
Administrators	3	17.5	19.09	4	31
University Lecturer	2	20.5	27.58	1	40
Adults	2	1371	1455	342	2400
MoE Officials	2	3.5	0.707	3	4
Communities	1	8	.	8	8
Tutors	1	71	.	71	71
ICT Heads of Departments	1	12	.	12	12
Parents	1	29	.	29	29
Curriculum Developers	1	80	.	80	80

Figure 1. *Boxplot of sample sizes in the articles included in the Kenya literature review.*

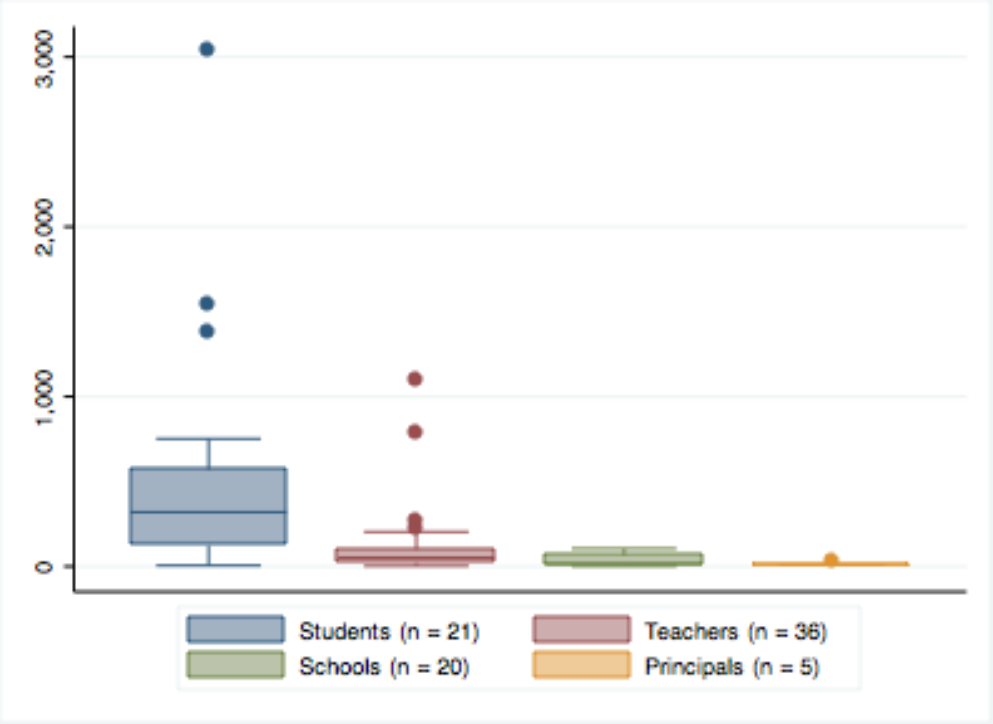
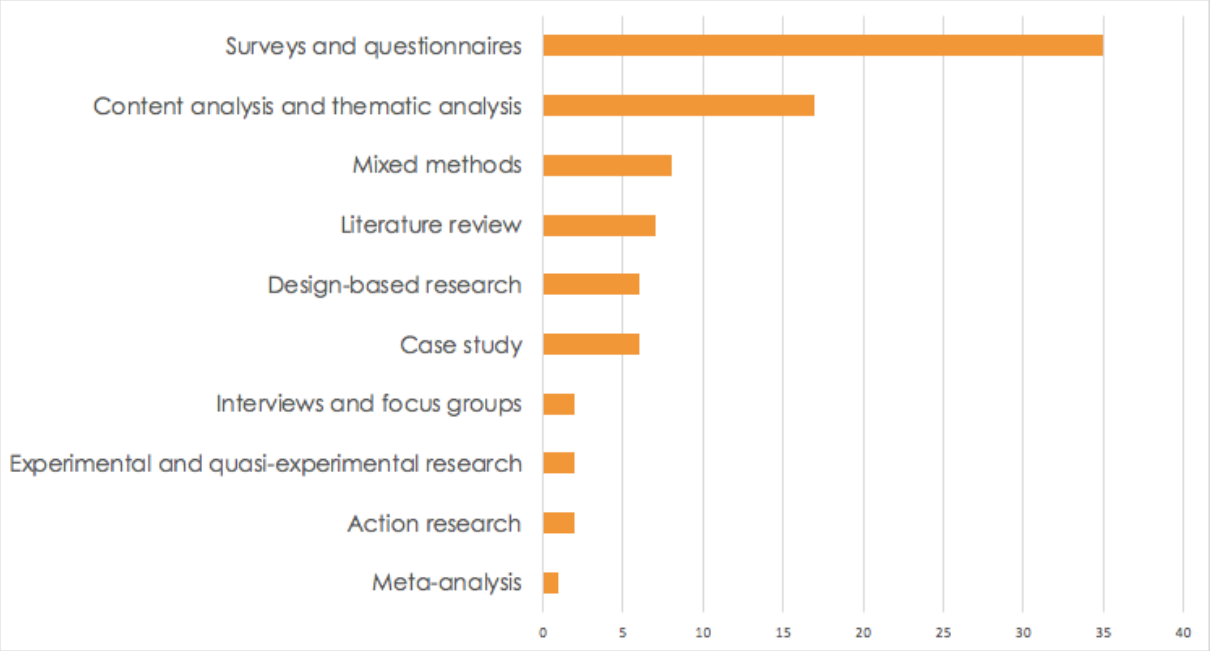


Figure 2. *Frequency of research methods using the RLI typology in the articles included in the literature review.*

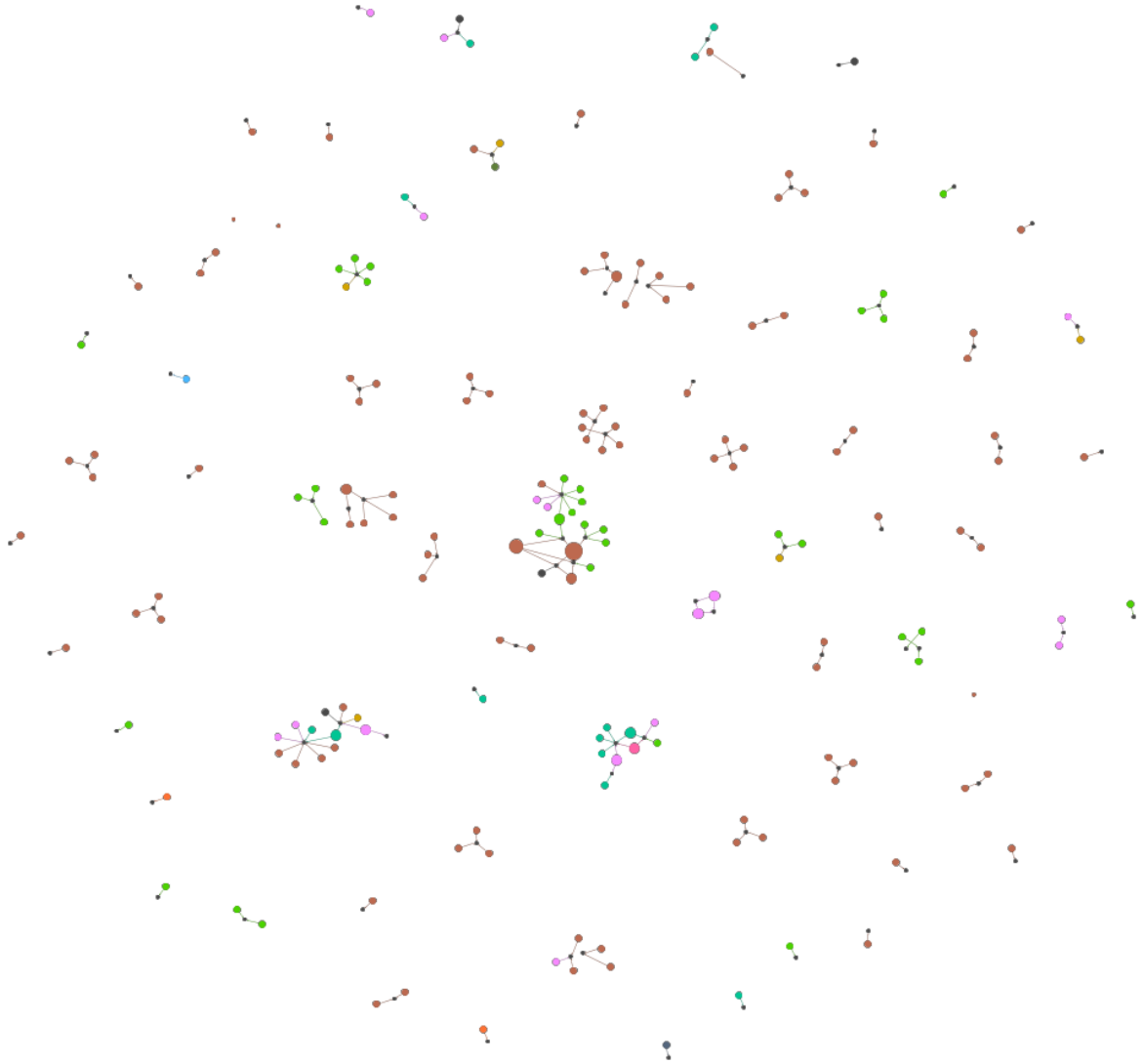


4. The key stakeholders within the research landscape on EdTech

This section provides an overview of some of the individuals and organisations active in conducting EdTech research in Kenya. The information in this section may not be exhaustive as most of this information is sourced from the rapid scan paper authored by Otieno & Taddese (2020), articles that have been published, and primarily academic journals. For example, researchers who have not published in outlets that are indexed by the databases, or are working on EdTech projects that have not yet reached the publication stage, are not included. Furthermore, the inclusion criteria for the literature review limited the search to EdTech in the context of school-aged learners, teachers, or aspects of the educational system relevant to school-aged learners; this would also exclude Kenya-based academics with EdTech research interests in relation to higher education (search terms for the literature review are listed in Annex A). Although the research strategy was intended to be as inclusive as possible, this source is unlikely to include all the individuals working on EdTech in Kenya. Nonetheless, the authorship of the articles included in the literature review is one way of exploring the academic research community with interests related to EdTech in the context of school-aged learners and teachers in Kenya.

Figure 3 depicts a co-authorship network of links between papers and their authors, within the reviewed academic literature. The characteristics of the data visualisation in Figure 3 reveal insights into the academic community related to EdTech research in Kenya. The many different nodes and independent clusters demonstrate a diverse ecosystem of research, able to support a wide range of work independently. This is also consistent with the observations extracted from the interviews conducted for this scoping review, which will be presented in Section 6. These refer to a fragmented landscape, with little collaboration among educational institutions.

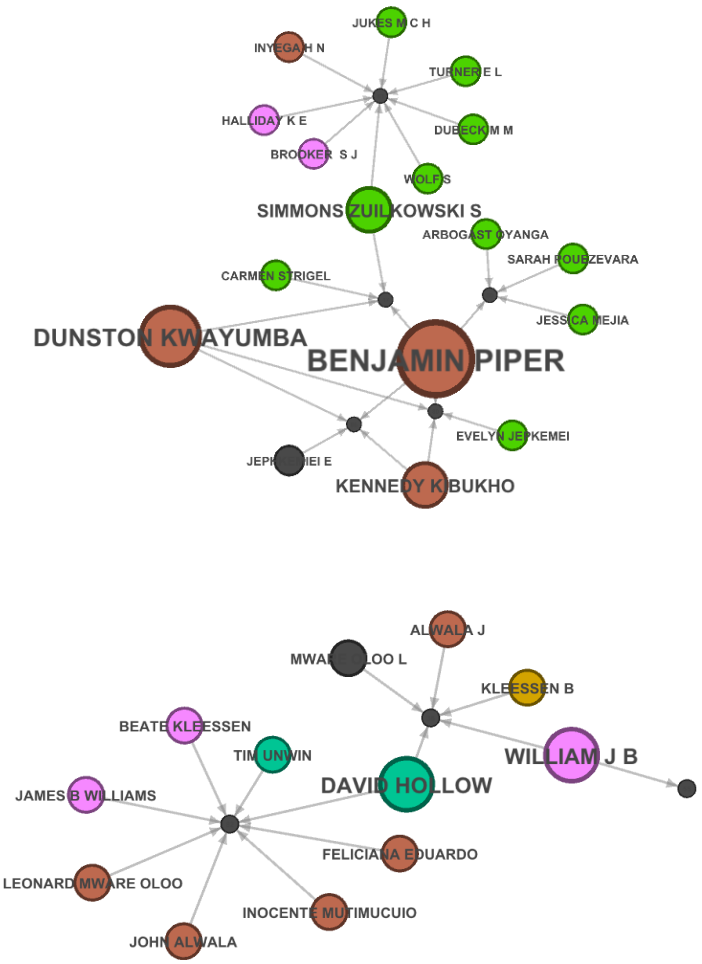
Figure 3. *Co-authorship network of the 87 papers included in the Kenya literature review. Links connect authors (coloured nodes) to articles (grey nodes). Node size is scaled according to the number of articles authored in the sample. East Africa (brown), USA (bright green), Europe (pink), UK (aquamarine), China (orange), South Africa (blue), South-east Asia (green), West Africa (bright pink), Australia (blue-grey). Authors who were not clearly associated with a particular location are shown in gold.*



As illustrated in Figure 4, the majority of the research projects (57%) are led by academic groups based in East Africa (mostly Kenya). A large number of academic groups (28%) are also led by researchers in the US and Europe (including the UK) and 10% of the studies were conducted by international collaborations. A co-authorship network graph shows a fairly dispersed EdTech research community highlighting opportunities to build further collaborations. However, a number of international collaborations do exist and three prominent research clusters have emerged (we highlight clusters where at

least one author is from East Africa, an author has been involved in two or more studies, and the authors have international collaborations). Two of these clusters include authors from East Africa.

Figure 4. *Co-authorship network of three of the largest research clusters in the EdTech literature for Kenya.*



This section will now turn to provide an overview of some of the key stakeholders that emerged primarily from the research literature review, with reference to the co-authorship network, arranged according to three sub-sections: first, academics based in Kenya; second, major EdTech projects; and third, research organisations with interests related to EdTech research in Kenya.

4.1. Leading academics and independent researchers

The distribution of authors affiliated with Kenya-based institutions in Figure 4 suggests that there is a large and active research community around EdTech; however, the co-authorship network is quite fragmented, which may suggest

that there is more scope for collaboration and network-building. Some of the most prominent Kenya-based academics, who have authored multiple papers in the sample and have online profiles, are listed below.

4.1.1. Benjamin Piper

Benjamin Piper is the Senior Director for Africa Education at RTI International, based in Nairobi, Kenya. Dr Piper provides technical support to programmes across the world and is the Principal Investigator for several RTI projects. Piper also supervises Kenya's national literacy programme: Tusome Early Grade Reading Activity (2014–2021) (see Section 4.2.1). Piper's interests include instructional improvement, policy reform, evaluation, and early childhood development. He has experience in programme management, instructional leadership, pedagogical improvement, policy analysis and assessment and has worked with the World Bank, the UK Department for International Development (now the Foreign, Commonwealth and Development Office (FCDO), UNICEF, and Save the Children.

4.1.2. Dunston Kwayumba

Dunston Kwayumba is a research, monitoring and evaluation specialist with over 10 years of experience in research as well as in programme monitoring and evaluation in Kenya. He has worked on various projects related to education, health, agriculture, and gender equality, in Kenya and internationally. He has also worked on a number of projects for the United Nations, Care International, USAID, SNV Netherlands, Save the Children International, the Swedish International Development Cooperation Agency (SIDA), World Bank, and the Government of Kenya.

4.1.3. Kennedy Kibukho

Kennedy Kibukho is a project management and monitoring and evaluation specialist with over 17 years' experience in project design, monitoring, evaluation, research, and learning and works across various sectors including water, sanitation, and hygiene (WASH), health, resilience, food security, gender, education, and advocacy. His expertise is action research and participatory programme design and monitoring and evaluation and he has overseen large-scale projects such as the ~$74 million USAID Tusome Early Grade Reading Program (see Section 4.2.1). He is currently at Tetra Tech International Development as the Monitoring and Evaluation Manager for its Africa Clean Energy Programme.

4.2. EdTech research projects

This section introduces an overview of some of the main large-scale EdTech research projects (in terms of number of learners reached) undertaken with relevance for the education of school-aged learners in Kenya. The purpose of this section is to provide an overview of the EdTech research projects found in the search. A closer look at the evaluation of these projects and their related empirical studies as well as reflections on potential research gaps that these studies have introduced are presented in Section 5.

It is important to recall that an acceleration in the development of new EdTech projects has been reported in Kenya, especially in the last five years (↑Otieno & Taddese, 2020). As this section focuses on presenting EdTech research projects, we considered it relevant to introduce other EdTech projects that were not evaluated by empirical studies or evaluation research, these are presented in Annex A in Section 9.

4.2.1. Tusome Programme

https://www.rti.org/impact/tusome-early-grade-reading-activity

Tusome, which translates as 'Let's Read' in Kiswahili, is a programme focused on enhancing Kenyan early grade literacy quality. It aims to strengthen early grade literacy practices in Grades 1, 2, and 3 in all 23,000 Kenyan public schools by:

- Providing paper-based educational materials and textbooks;
- Training all teachers of Grades 1–3 in the new early grade literacy approaches;
- Training Civil Society Organisations (CSOs) in new approaches to enable them to support teachers;
- Training senior leaders to use Tusome data to identify and address education system gaps (↑U.S. Embassy in Kenya, 2016; ↑Kaye, 2020)

EdTech is applied in Tusome to support teacher coaching and oversight. All CSOs receive tablets to capture classroom observations and to collect data. The findings of the evaluation of *Tusome* (↑Piper, et al.,2017; ↑Kaye, 2020) are explored further in Section 5 (see Section 5.2 and Section 5.3).

4.2.2. PRIMR

https://pdf.usaid.gov/pdf_docs/pa00k285.pdf

Before Tusome, the Primary Math and Reading (PRIMR) Initiative was a 547-school research study supported by USAID/Kenya and undertaken by the Ministry of Education with support from RTI International (↑Piper & Kwayumba, 2014). This programme was targeted at improving reading and mathematics outcomes in grades 1 and 2 in Kenya and included the use of tablets for students, teachers and instructional supervisors (Piper et al., 2015.

4.2.3. TESSA MOOCs

http://www.tessafrica.net/home

TESSA (Teacher Education in Sub-Saharan Africa) is a network of teachers and teacher educators that intends to create and implement initiatives targeted at improving classroom teaching practices in various African countries. TESSA MOOC is an initiative for capacity building that is based on facilitating online courses on teacher professional development (TPD) for Kenyan teachers and teacher educators. This initiative and overall approach were evaluated by ↑Wambugu (2018) and the findings of this evaluation are presented in Section 5.2.

4.2.4. JiFUNzeni

https://eric.ed.gov/?id=EJ1020952

JiFUNzeni means 'inviting all to learn' in Kiswahili and is an approach targeted at providing TPD opportunities that was developed by researchers at the Aga Khan University. This approach is implemented through providing training to different stakeholders, which is targeted at enabling them to create learning material for teachers in a given context, choosing appropriate technologies for teacher development while building content repositories. This approach was applied and evaluated by ↑Onguko (2014) and involved 36 teachers using the tools created in two different regions, namely in rural western Kenya and in Nairobi (in Korogocho) (see Section 5.2)

4.2.5. Digital Literacy Programme

http://icta.go.ke/digischool/

The Digital Literacy Programme is a programme that emerged from the Government of Kenya's vision to make sure every child is "prepared for today's digital world and to transform learning in Kenya into a 21st-century education system" (↑ICT Authority, no date). The Digital Literacy Programme (DLP)

delivers laptops and tablet devices pre-loaded with interactive digital content in maths, English, science and Kiswahili, to primary school teachers and pupils to enhance their classroom activities. This programme was discussed by ↑Piper, et al.(2017) and ↑Kaye (2020) and is further illustrated in Section 5.3.

4.2.6. Uwezo

https://www.uwezo.net

Uwezo means 'capability' in Kiswahili. Uwezo is a five-year initiative that started in 2010 that aimed to improve competencies in literacy and numeracy among children aged 6–16 years old in Kenya, Tanzania, and Uganda. It is based on using an EdTech to contribute to a 10% increase in basic literacy and numeracy competencies for children in Kenya. This initiative was evaluated by the study of ↑Koomar & Blest (2020) and is presented in Section 5.3.

4.2.7. Worldreader

http://www.worldreader.org/

Worldreader works with partners to enable children in underserved communities and from marginalised backgrounds to access digital books. Worldreader supports reading programmes in the United States, East Africa, West Africa, India, Latin America, and the Middle East and North Africa. Worldreader works in dozens of schools and libraries across East Africa, and millions of readers access their library via their mobile phones in this region. One of their projects, known as 'LEAP', brought digital reading to all 61 public libraries in Kenya.

4.2.8. Instant Network schools

https://www.un.org/partnerships/content/instant-network-schools-programme-united-nations-high-commissioner-refugees-unhcr-and

Instant Network Schools was set up in 2013 by Vodafone Foundation, UNHCR, and the UN Refugee Agency to give young refugees, host communities and their teachers access to digital learning content and the internet, to improve the quality of education in some of the most marginalised communities in Africa. There are 36 Instant Network Schools currently operating across eight refugee camps in Kenya, Tanzania, the Democratic Republic of Congo, and South Sudan. They have been working in 20 schools in Kenya, as of June 2021. This initiative is further presented in the study of ↑Joynes & James (2018) and discussed further in Section 5.4.

4.3. Academic institutions, research centres, and independent organisations working in education and EdTech

This section gives an overview of some of the academic institutions, research centres, and independent organisations that prominently appeared in the authorship of the articles and papers selected for this review. The search illustrated that academic institutions, national as well as international, are the main source of EdTech research funding for Kenya and contribute to more than 70% of the literature's funding sources. Kenyatta University is one of the most prolific research institutions in the EdTech space in Kenya and has produced over a quarter of the publications found (see RLI- accessible here). This is followed by Moi University, EdTech Hub, Mount Kenya University, and RTI international. Other institutions are the Aga Khan University, Maasai Mara University and the University of Nairobi.

4.3.1. Kenyatta University

http://www.ku.ac.ke

Kenyatta University is a public research university and its main campus is in Nairobi County. This university has an 'Educational Communication and Technology' department that was established in 1986. This department has been acting as a leading entity in EdTech research in Kenya. Some publications emerging from this department include the research of ↑Miima et al. (2013), ↑Amuko et al. (2015), and ↑Ngatia (2015). These sources are presented and discussed in Sections 5.2 and 5.3.

4.3.2. Moi University

https://mu.ac.ke

Moi University is a public university located in Kesses, Uasin Gishu county, in the former Rift Valley Province of Kenya. Moi University recently launched an education technology research programme and is now the university with the second-highest number of EdTech publications in Kenya (after Kenyatta University), examples of such publications include the ones authored by ↑Mwei et al. (2011), ↑Tonui et al. (2018), and ↑Akinyi (2015). These sources are also presented and discussed in Sections 5.2 and 5.3.

4.3.3. RTI international

https://www.rti.org

Research Triangle Institute, trading as RTI International, is a nonprofit organisation headquartered in the Research Triangle Park in North Carolina.

RTI provides research and technical services to address various global issues with science-based solutions and research. RTI International has worked with educational programmes / reforms in Kenya for nearly 40 years and one of the prominent Kenya-based academics emerging from the co-authorship network — Benjamin Piper — is affiliated to RTI (see Section 4.1.1). RTI developed a mobile assessment and coaching tool called 'Tangerine™', which is an EdTech software application that can be used for offline data collection on low-cost Android tablets. Tangerine ™, and its use during the Tusome programme, is discussed in Section 5.3.

4.3.4. Education Development Trust

https://www.educationdevelopmenttrust.com/

Education Development Trust works collaboratively with national and local governments, schools, and other stakeholders to design and deliver solutions to improve education in Kenya and globally. Their work is evidence-informed and they invest annually in various programmes of educational research. The Education Development Trust facilitated the Wasichana Wetu Wafaulu programme in Kenya, which is part of the UK-funded worldwide Girls' Education Challenge (GEC). Wasichana Wetu Wafaulu is a six-year programme that is aimed at supporting a cohort of about 72,000 girls to complete their current phase of education and achieve improved learning outcomes.

5. Summary of the evidence on EdTech

The purpose of this section is to provide an overview of existing evidence and to highlight potential opportunities for future research. Drawing on the Research Landscape Index (RLI) framework discussed in Section 3 (accessible here), the literature is thematically analysed and organised into five research topics of interest to EdTech Hub:

1. Technology to support personalised learning and teaching at the level of the student;
2. (In-service) teacher professional development, structured pedagogy, and technology;
3. Technology to advance data-use and decision-making in education;
4. Technology to promote access and participation in school;
5. Girls' education and technology.

The reported synthesis is intentionally — and necessarily (given the constraints of the scoping review methodology) — based on introducing research and prioritising empirical studies, without discussing them in a high level of detail. It intends to provide an accessible summary of existing evidence to inform educators, policymakers, and donors. Bibliographic details of all studies included and detailed coding of these studies can be found here.

5.1. Technology to support personalised learning and teaching at the level of the student

Research suggests that using technology to support personalised learning can be effective in increasing learner access to education, enabling targeted instruction by the learning levels of the students, and reducing the negative effects of high teacher–learner ratios (↑Major & Francis, 2020). As in many LMIC settings, however, in Kenya, there is currently a lack of rigorous evidence for how technology can be used most effectively to personalise learning to the right level in an effective, cost-effective, and contextually appropriate way.

The search revealed 14 papers that mention personalised learning (↑Redempta, 2012; ↑Obonyo, 2013; ↑Rugut & Role, 2013; ↑Kirimi, 2013; ↑Jobe, 2013; ↑Kaindio & Wagithunu, 2014; ↑Kisirkoi, 2015; ↑Pedersen, 2015; ↑Ndaiga & Salim, 2015; ↑Kingori, 2018; ↑Araka et al., 2019; ↑Heinrich et al., 2020; ↑Ng'ang'a et al., 2020; ↑Ngari & Ndung'u, 2020). The vast majority of the papers (n = 12) mention that technology has the potential to support personalised learning and, in turn, to improve learning outcomes. However, only one paper in the search provides a

study where technology is applied for personalised learning, noting that the proposed intervention was only partially evaluated (↑Heinrich et al., 2020). This empirical study explored how technology supporting personalised learning was used in North Kamagambo primary schools. The study was based on offering tablets with literacy applications that invited children to read at their own pace and to address their individual learning needs by accessing features enabling them to adjust the font size and look up words that they did not understand (ibid). The authors concluded that the role of technology for personalised learning needed to be evaluated by considering local infrastructures and potential barriers in accessing technology, pointing out that a one-to-one tablet-to-student ratio was only observed for 32% of children in their study. They concluded by saying that this limited "the ability of students to take full advantage of features that facilitated personalised learning" (ibid, p. 23).

Although only briefly mentioned in the study of ↑Heinrich et al., 2020, the costs of technology to support personalised learning need to be acknowledged in this scoping review. Some of these costs might be related to the number of devices needed for such EdTech interventions but they could also be associated with the technical complexities and hardware expenses often needed to design technology-supported personalised learning tools. This was briefly discussed in a study that proposed a model for measuring and supporting self-directed learning opportunities in Kenya (↑Araka et al., 2019). The authors presented some challenges and required investments to implement and design technology-supported personalised learning interventions, mentioning that "offering individualized support and guidance may not easily be achieved because of large numbers of students enrolling in e-learning" (↑Araka et al., 2019, p. 2). To use technology to support personalised learning in a sustainable way, and especially in low-resource contexts, a range of challenges need to be addressed, such as resource constraints, lack of technical expertise and infrastructure. These are challenges that continue to emerge in research exploring the role of technology-supported personalised learning in LMICs (↑Kaye & Ehren, 2021).

The search also reveals two papers introducing specific opportunities and needs related to personalised learning in Kenya. In an exploratory study intending to provide recommendations related to improving EdTech interventions by considering personalised learning features, the authors reported that translation features had significant potential to enable more children to access and benefit from EdTech in Kenya. They argued that exclusively using English in EdTech could imply that many Kenyan children would be unable to comprehend the educational content of EdTech interventions (↑Ngari & Ndung'u, 2020, p. 89). The authors also mentioned that

the potential of self-paced learning features could also be used to improve learning outcomes for children (ibid. p. 89). In the search, another exploratory study on personalised learning was found. This study is based on illustrating the challenges secondary schools in Kenya face when using EdTech and also called for more personalised learning features to adapt to local language needs (↑Kirimi, 2014). Despite limited evidence and empirical studies on the use of EdTech to support personalised learning in Kenya, the search revealed two papers illustrating potential needs to use personalised learning to improve educational outcomes in Kenya, — namely, the need to use personalised learning to align EdTech interventions to varying language and self-paced learning needs.

Overall, there is currently a lack of rigorous evidence and empirical studies exploring how technology can be used most effectively to personalise learning in an effective, cost-effective, and contextually appropriate way in Kenya. The limited evidence found in the search illustrates a research gap, i.e. to further examine how technology-supported personalised learning can be used effectively to improve learning outcomes in Kenya. The role of teachers and parents in shaping technology-enabled personalised learning effectively is also an area where additional research is needed. This is in addition to research needed to explore whether (and if so, how) personalised approaches that feature technology that can adapt or adjust to learners' individual needs are effective in leading to better learning outcomes.

5.2. Teacher professional development, structured pedagogy, and technology

In total, 35 papers within the literature review were categorised under the theme of 'teachers'. Research on teacher professional development (TPD), and integration of technology into classrooms / pedagogies, is mainly focused on the following areas in Kenya:

- Technology modalities and blended approaches to teacher development (n = 8);
- Using technology to develop and support facilitators and coaches (n = 4);
- Teachers technology adoption (n = 16).

Note, these categories are not mutually exclusive and in some cases included articles related to one or more of these areas (for instance, many examine both teachers' needs and technology adoption and these are considered together).

5.2.1. Technology modalities and blended approaches to teacher development

The search revealed six papers (↑Kaindio & Wagithunu, 2014; ↑Amuko, et al., 2015; ↑Gitome, 2015; ↑Radhakrishnan, et al., 2018; ↑Wambugu, 2018, ↑Bett & Makewa, 2020) that discussed technology modalities for teacher development and two papers exploring blended approaches for TPD (↑Onguko (2014; ↑Hooker, 2017).

Two empirical studies were found on the topic of technology modalities for teacher development: one evaluated the use of MOOCs for TPD and the other one discussed TPD delivered through online support groups (↑Wambugu, 2018; ↑Bett & Makewa, 2020). The following paragraph introduces these two studies.

The TESSA (Teacher Education in Sub-Saharan Africa) MOOC is an initiative based on facilitating online courses for Kenyan teachers and teacher educators. ↑Wambugu's (2018) study was based on evaluating teachers' experiences (n = 93) and presented findings targeted at informing and improving interventions using MOOCs for TPD. These findings illustrated the importance of facilitating interactive activities among teachers, allowing self-regulated scheduling, presenting practical educational content and awarding certificates at the end of TPD-related MOOCs. The authors concluded their study by saying that "MOOCs represent an untapped potential for teacher professional development that can be a cost and resource-effective means to deliver quality education to teachers and teacher educators." (↑Wambugu, 2018, p. 1). The second study involved teachers (n = 1100 teachers) and aimed to explore the use and impact of teacher-led online forums and groups on Facebook for TPD (↑Bett & Makewa, 2020). It revealed that teacher-led groups on Facebook were suitable to facilitate TPD opportunities as they enabled teachers to start conversations, ask questions and / or share resources (↑Bett & Makewa, 2020). The authors concluded by saying that,

> *"The temptation, especially by government educational agencies, is to create a formal online platform where teachers can grow and interact professionally. While such a move is laudable and bound to work, it is important to understand the characteristics of informal teacher-led online forums, which may not apply to formally organised ones."* (↑Bett & Makewa, 2020, p. 12)

The evidence landscape on blended approaches to teacher development in Kenya is nascent, in total, two studies discussing this theme were found in the

search (↑Onguko, 2014; ↑Jukes et al., 2017). These are presented in the following paragraph.

The study of ↑Jukes, et al. (2017) was presented as an initiative aiming at using TPD to improve children's literacy outcomes in Kwale county. This study was based on training workshops, lesson plans, and weekly text messages for teachers and was evaluated in 101 schools. Text messages were used to enable teachers to access instructional support. Teachers were given the opportunity to reply to messages with weekly phone credit. The authors reported that,

> *"The response rate to text messages was high (an average of 87%) and teachers told us that they valued the support provided by these messages. They were successful in creating a sense of community, making teachers feel valued and listened to, and being an important mechanism for feedback and improvement of the intervention."* (↑Jukes, et al., 2017, p. 27)

The other study related to this topic was conducted by ↑Onguko (2014) and presented a blended approach to teacher development called JiFUNzeni (JiFUNzeni means 'inviting all to learn' in Kiswahili). The JiFUNzeni approach is based on training regional educators to create blended learning courses, choosing appropriate technologies in a given context while building content repositories for TPD. This approach was evaluated (n = 36 teachers) in two different regions, namely in rural western Kenya and in Nairobi (in Korogocho). Lessons from the implementation of the jiFUNzeni approach reinforced the importance of considering contextual realities in implementing TPD through blended learning approaches as well as variations related to infrastructural and TPD needs in different contexts. In this study, the teachers in rural western Kenya needed to learn about suitable practices to teach in large class sizes, while teachers in Korogocho needed professional development opportunities targeted at improving assessment processes.

To summarise, examples of solutions using technology for TPD were presented, and preliminary indications on the suitability of teacher-led online platforms and MOOCs for TPD were reported. Future research could build on these studies to analyse the impact of technology-supported TPD interventions on teachers' development / learning and classroom practices. Following this, little research was found on blended learning approaches to teacher development and only one study (↑Onguko (2014) integrated local and contextual factors in the design of the proposed TPD intervention. Future research could be conducted by collecting and analysing data throughout

technology-supported / blended TPD interventions to assess the needs and requirements that teachers have in different contexts where they operate. This could lead to presenting evidence related to designing technology-supported TPD interventions that are contextually appropriate and responsive to well-defined and existing needs.

5.2.2. Using technology to develop and support facilitators and coaches

In total, four papers discussing the inclusion of facilitators and coaches in relation to technology-supported TPD interventions were found in the search (↑Piper, et al., 2017; ↑Radhakrishnan, et al., 2018; ↑Piper et al., 2018; ↑Kaye, 2020). All of these papers discussed the Tusome programme, which focused on improving the level of Kenyan children's early grade literacy. This programme was mainly targeted at improving teacher quality and leveraged technology to improve children's literacy learning outcomes (more details about this programme were presented in Section 4.2.1). Tusome is lauded as a successful intervention relying on using EdTech to develop and support teachers and coaches, as it significantly improved national learning outcomes related to children's literacy, and the use of tablets positively impacted teacher behaviours (↑Kaye, 2020). Some of the factors that contributed to these outcomes were reported in a study conducted by ↑Kaye (2020), some of which are summarised below:

- The Tusome programme facilitated training on literacy pedagogies to both teachers and coaches, targeted at collaboratively improving teaching practice.
- The programme also introduced clear roles and responsibilities within this programme for teachers and coaches.
- Fostering trust among teachers and coaches was a key success factor. Tusome achieved this through clear, transparent communication.
- Training to enable coaches to use tablets was part of this programme. The tablets were introduced as devices to promote transparency and accountability, encourage constructive feedback, and share responsibility.
- The tablets were used as a tool to support a very specific aspect of teacher coaching.

This programme was implemented with the intention to tackle what was described by ↑Piper, et al. (2017) as "the most prevalent educational problem in Kenya" (p. 75), which is attributed to poor instructional quality. The tablets were

provided with tools targeted at supporting coaches to gather observation data during school-based inspections and to provide instructional improvement support to teachers, which in turn intended to lead to improved accountability structures in Kenya's education system. The evaluation of this programme, mostly targeted at exploring its effectiveness to collect classroom observations and to improve children's learning outcomes, showed results illustrating high levels of tablet use, increased accountability, and improved children's learning outcomes. "The consistent increases over time in the numbers of classroom observations undertaken by coaches suggest that the accountability system is functional and that the coaches see the classroom observation tasks as important" (↑ibid., 2017, p. 72). This evaluation also concluded that it is necessary to apply EdTech to a "specific instructional challenge in order to see positive results." (↑ibid., 2017, p. 74).

Overall, the presented studies illustrated that the Tusome programme focused on building the capacity of its teachers and coaches, leveraging the use of tablets only in so far as it supports this goal. Clear communication and a common strategy, shared among the different stakeholders involved, allowed the programme to establish trust among internal and external stakeholders alike. Potential future work relating to the inclusion of facilitators and coaches in relation to technology-supported TPD initiatives is described in the concluding section of the analysis provided by ↑Piper et al., 2018. After arguing that the Tusome programme could be illustrated as a programme that facilitated basic inputs for teachers to access pertinent TPD opportunities, and for children to access educational resources, the authors state that "The bigger challenge for the education system going forward is developing the capacity to ensure ongoing support of the type that enables teachers and students to make good day-to-day use of those basic inputs" (↑ibid., p. 317).

5.2.3. Technology adoption by teachers

Lack of ICT knowledge and unsuitable network infrastructure are some of the biggest barriers to enabling teachers to adopt technology in classrooms. In total 16 studies exploring the topic of technology adoption by teachers were found (↑Kiptalam & Rodrigues, 2010; ↑Ogembo, et al., 2012; ↑Miima, et al., 2013; ↑Mulwa & Kyalo, 2013; ↑Mbogo, et al., 2014; ↑Kaindio & Wagithunu, 2014; ↑Gitome, 2015; ↑Amuko, et al., 2015; ↑Chemwei, et al., 2016; ↑Jukes, et al., 2017; ↑Hooker, 2017; ↑Mwanda et al., 2017; ↑Kaume-Mwinzi, 2018; ↑Ochieng & Miima, 2019; ↑Muinde & Mbataru, 2019; ↑Bett & Makewa, 2020). The following paragraphs will highlight some of these studies, prioritising the ones that presented empirical findings.

Out of these 16 papers, six of these included studies targeted at collecting data on teachers' attitudes and perceptions related to EdTech use. Teachers'

perceptions are described as a factor that can influence technology adoption in and outside of classrooms, as negative perceptions toward technology can discourage teachers from putting EdTech into use. In total five studies (n = 5) presented results illustrating positive teachers' perceptions related to the potential of EdTech to improve children's learning outcomes in Kenya (↟Miima, et al., 2013; ↟Mulwa & Kyalo, 2013; ↟Mbogo, et al., 2014; ↟Ochieng & Miima, 2019; ↟Muinde & Mbataru, 2019) and divergent results illustrating negative perceptions were found in one study (↟Hooker, 2017). Additional findings related to teachers' perceptions were found in some of these studies. ↟Mbogo, et al. (2014) presented results illustrating that teachers and administrators in various counties (n = 30 teachers and n = 31 administrators) perceived issues related to school administration and management as having the greatest potential for improvement with the use of technology. ↟Miima, et al. (2013) presented evidence reinforcing that perceptions should only be presented as a factor that influences EdTech implementation and use. Their study presented findings illustrating that the majority of teachers interviewed (n = 45 teachers) had positive perceptions of EdTech use but were unwilling to implement technology in their classrooms. Reasons for this ranged from challenges related to a lack of skills and confidence with using technology and reticence related to spending time understanding different kinds of software to a lack of knowledge needed to integrate EdTech into classrooms.

The need for in-service TPD of ICT skills was also revealed in the search. In total, 11 papers illustrated the need for TPD training to support teachers in integrating EdTech into pedagogies and in their classrooms (↟Kiptalam & Rodrigues, 2010; ↟Ogembo, et al., 2012; ↟Mulwa & Kyalo, 2013; ↟Kaindio & Wagithunu, 2014; ↟Mbogo, et al., 2014; ↟Amuko, et al., 2015; ↟Chemwei, et al., 2016; ↟Mwanda et al., 2017; ↟Kaume-Mwinzi, 2018; ↟Nyaga, 2018; ↟Muinde & Mbataru, 2019). The majority of these papers (n = 9) argued that governmental and political priorities should involve and allocate resources to the implementation of training to support teachers in acquiring ICT and digital literacy skills as part of TPD curriculums. For example, a study including teachers (n = 89) randomly selected from a total of 468 teachers in Kenyan secondary schools in various counties illustrated that most teachers who were required to implement EdTech in their classrooms had low levels of digital literacy and had not received any training related to using digital devices in classrooms (↟Kiptalam & Rodrigues, 2010). Aligned with these findings, research involving teachers (n = 169) in six primary schools in different regions in Kenya presented findings related to the use of computers in classrooms. The results suggested that most teachers were lacking the skills to use computers in their classrooms, leading them not to use them as part of their teaching practices. The authors recommended facilitating ICT and digital

literacy training for future teachers as part of university and governmental curriculums (↑Chemwei, et al., 2016). Another study carried out in twelve public schools in Nairobi presented evidence of the lack of resources allocated to TPD for improving digital skills that would enable teachers to use EdTech in classrooms and schools. This study also presented insights on the benefits of allocating resources to facilitate formal in-service TPD of ICT skills, by presenting results pointing to poor outcomes when informal training or self-training were encouraged (↑Amuko, et al., 2015).

The Digital Literacy Programme (DLP) is another case study that illustrates how teachers' perceptions and capacity development, among other factors, can influence the outcomes of an EdTech intervention. The DLP was announced in 2013 and aimed to enable all Kenyan school children to access laptop computers (see Section 4.2.5). This programme went through several iterations, which progressively narrowed its scope and led teachers to develop negative perceptions towards this programme over time (↑Kaye, 2020). In May 2016, the government advised that the DLP would provide all Grade 1 students in Kenya with tablets and all teachers with laptops (↑Kaye, 2020 citing ↑Wanzala & Nyamai, 2018). The programme's implementation began in 2016 and delivered significant achievements within six months, including training approximately 70,000 teachers by mid-2016, creating online content for Grades 1 and 2 (in Kiswahili, English, mathematics, science, and social studies) and providing electricity to all but 500 schools in Kenya (↑Mariga et al., 2017; ↑Kaye, 2020). However, various challenges limiting the realisation of the programme's intended outcomes started to emerge shortly after this. It was reported, that even two years later, in July 2018, only 19,000 of the 23,000 schools had received devices (↑Kaye, 2020 citing ↑Wanzala & Nyamai, 2018). Enabling teachers to use the new devices acquired was also problematic as only 70,000 teachers (out of approximately 250,000) had accessed professional development training by the end of 2017. It was later found that approximately a third of teachers involved in this programme were not using the tablets in their classrooms despite having received them, leading ↑Kaye (2020) and ↑Nyaga (2018) to argue that the lack of capacity development combined with teachers' negative perceptions of the programme contributed to this limited update. ↑Kaye (2020) added that "The DLP provides an excellent example of the importance of considering trust, capacity and accountability when designing and implementing EdTech interventions. Overlooking these elements played a large part in the eventual failure of the DLP." (↑Kaye 2020, p. 193).

In total, six studies focusing on analysing teachers' attitudes and perceptions of EdTech use were found, which suggests that teachers' attitudes and perceptions are considered important factors in influencing the

implementation of EdTech interventions in Kenya. There was another clear convergence in the papers reviewed, which pointed to the urgency of the need to shape governmental and political priorities to support teachers to acquire ICT and digital literacy skills as part of TPD curriculums. The ongoing, continuous nature of professional development that is needed to support the sustained adoption and effective use of EdTech by teachers received little attention in the studies found. We consider this an important area for future research and EdTech decision-making, as illustrating the ongoing and continuous nature of TPD could contribute to gradually improving teaching practices and creating sustainable impact. Overall, evidence related to shaping TPD opportunities to enable Kenyan teachers to efficiently use digital technologies in the classroom seems limited. This area could be explored by integrating key characteristics of effective teacher learning and digital literacy, such as peer learning, encouraging the practical application of teaching methods and helping teachers to gain confidence with using digital devices.

5.3. Technology to advance data use and decision-making in education

Technology could enhance the quality of education by using it for the purpose of informing decision-making as well as the collection and analysis of data. However, many LMICs lack the technology-enabled mechanisms and resources to collect and analyse such data, let alone using it to make informed decisions about education policy and systems.

The search contained 22 papers that discussed technology to advance the use of data and decision-making in education. The literature falls within four main categories:

1. Accountability (n = 4);
2. Role of handheld devices for data collection and analysis (n = 6);
3. Technology to measure the performance of learners (n = 4);
4. Policy planning and system strengthening (n = 8).

These categories are not mutually exclusive and in some cases, papers cover one or more of them.

5.3.1. Accountability

The search revealed four papers that discuss the theme of data and technology to encourage accountability (↑Koomar & Blest, 2020; ↑Ngari & Ndung'u, 2020; ↑Rodriguez-Segura, 2020; ↑Kaye, 2021). Technology to

encourage government accountability is touched on in a literature review that assesses how prepared the Kenyan education system was to overcome challenges caused by Covid-19 (↑Ngari & Ndung'u, 2020). The authors argued that the National Education Management Information System (NEMIS), which is the Kenyan Ministry of Education's (MoE) data management system, should further solidify and support effective collection and use of data for educational accountability (↑Ngari & Ndung'u, 2020, p. 93). The use of data for accountability in Kenya is also discussed in a paper that explores the use of EdTech for data monitoring, including the use of technology to encourage parental accountability (↑Koomar & Blest, 2020). The authors refer to Uwezo, a five-year programme starting in 2010 that was implemented by a non-profit local organisation of the same name, which aims to improve the literacy and numeracy of children ranging from 6–16 years of age in Kenya, Tanzania, and Uganda. The programme captured data related to children's literacy and numeracy in the hope that this information would be used as part of advocacy and / or communication strategies to "encourage parents' advocacy for better education services and [...] incentivise governments to focus on learning outcomes and improve education quality" (↑Koomar & Blest, 2020, p. 11). Technology to encourage parental accountability is also discussed in an exploratory analysis of technology use in developing countries (↑Rodriguez-Segura, 2020). The author refers to a mobile money platform active in Kenya (no name is given), which could lock the savings accounts of parents who were imminently due to pay educational fees for their children (↑Rodriguez-Segura, 2020, p. 22). Although not empirically measured in the paper, it appears that the platform prevented parents from spending money that could jeopardise their ability to pay for their children's education.

A critical challenge to the use of data for accountability processes in Kenya is related to the autonomy of various bodies that are part of the public education system. For example, the Teachers Service Commission (TSC) is the national agency responsible for teacher management processes and accountability in Kenya. According to ↑Kaye (2021), the TSC's growing independence from the MoE has contributed to creating additional challenges related to collecting education-related governance and accountability data in Kenya (↑Kaye, 2021, p. 186). Tusome is presented as a programme that delivered a culture of supportive development, coordination, and trust between various national stakeholders. For example, the teachers and the Curriculum Support Officers involved in this programme were given clear roles and responsibilities in addition to shared and collaborative objectives (e.g., to use technology to support teachers in a non-punitive manner). According to Kaye, this and other measures implemented in Tusome created "a feeling of collaborative accountability for children's learning" (↑Kaye, 2021, p. 195).

This section illustrates that additional evidence and best practices related to using data to encourage and / or increase accountability throughout EdTech decision-making processes in Kenya are needed. The studies introduced in this subsection suggest that it could be relevant to conduct empirical research into how effective, and why, Uwezo and the mobile money platform presented above (and potentially other / upcoming interventions), were in encouraging greater accountability by the government, teachers and / or parents in Kenya. In addition, in light of Tusome's success, it could also be beneficial for the MoE to explore ways to collaborate with the TSC and other autonomous education bodies in order to incentivise teachers, and potentially other stakeholders, to explore how to efficiently collect data that could be used for accountability and to measure learning outcomes in Kenya.

5.3.2. Role of handheld devices for data collection and analysis

The literature search reveals that certain handheld devices could play a positive role in the collection and analysis of data for education in Kenya. The role of handheld devices in data collection and analysis is discussed in six papers (↑Haßler et al., 2020; ↑Kaye, 2021; ↑Koomar & Blest, 2020; ↑Heavner et al., 2017; ↑Mayeku et al., 2010; ↑Piper et al., 2015). Tusome is referenced and discussed in three of the papers (↑Haßler et al., 2020; ↑Kaye, 2021; ↑Koomar & Blest, 2020). Tusome involves various strands of activity related to using handheld devices for data collection and analysis (also discussed in Section 5.2), including supporting Curriculum Support Officers to use tablets to capture school-level data as well as the implementation of mechanisms to analyse data to illustrate regional and national challenges. According to ↑Kaye (2020), the use of tablets as well as fostering trust among teachers and the Curriculum Support Officers were two of the factors that made data "more accessible and transparent" (↑Kaye, 2020, p. 196). Tablet use was introduced alongside pedagogical and technology training opportunities, which were also illustrated as factors that contributed toward enabling the Curriculum Support Officers to collect quality data (↑Kaye, 2020).

Besides Tusome, 'Sauti za Wananchi' is another example that presented insights on how handheld devices could be used for processes of data collection. Sauti za Wananchi is an interactive mobile phone survey that gathers citizens' opinions on a wide range of issues, including education (↑Koomar & Blest, 2020). The collected data can also be viewed on an online public platform that aims to present data that could be used to inform citizens and policymakers. It is important to note that initiatives like Sauti za Wananchi, which depend on the use of certain handheld devices and data connections, run the risk of exacerbating inequalities in low-resource environments. This

was reported by ↑Koomar & Blest (2020) who mentioned that people without mobile phones and certain mobile network coverage were excluded from participating in this initiative. When designing programmes that rely on the use of certain handheld devices, consideration should be given as to whether potential users have access to the infrastructure and resources necessary for participation, such as mobile phone handsets, mobile phone coverage and data packages. If such infrastructure and resources are not available, programme implementers could be required to explore additional or alternative measures to access such groups.

5.3.3. Technology to measure the performance of learners

The search contains four papers that discuss the role or potential of technology to measure the performance of learners (↑Akinyi, 2015; ↑Koomar & Blest, 2020; ↑Ndaiga & Salim, 2015; ↑Piper et al., 2016). The search presents two programmes using technology to measure the performance of learners — Uwezo and Tusome (↑Koomar & Blest, 2020). Uwezo, which was discussed previously, used household surveys to conduct annual assessments of children's literacy and numeracy levels. The other example is Tusome, which has been discussed at length in other sections of this scoping review. Both ↑Koomar & Blest (2020) and ↑Piper et al. (2016) discuss Tangerine™, which is an open-source early learning assessment software developed by RTI International (see Section 4.3.3.) used to collect data on learner performance that was used as part of Tusome. ↑Piper et al. (2016) argued that Tangerine™ facilitated a highly accurate measurement of student performance, for instance, because the software included features that made it possible to collect targeted and individual data by adapting to the children's divergent learning tasks and progress (↑Piper et al., 2016, p. 208)

Uwezo and Tusome's presentation as the only two examples of programmes using data-driven technologies to measure the performance of learners suggests that the use of technology in this respect is not widespread, a point that was also argued by ↑Ndaiga & Salim (2015). Given the global and increasing use of Tangerine™, it could be relevant for policymakers, researchers, and programme implementers to consider what software features and factors are needed to contextualise technology use to support collecting and analysing data to measure and improve learning outcomes and performances.

5.3.4. Policy planning and education system strengthening

Eight papers discussing the role of technology in policy planning and the strengthening of education systems emerged from the search (↑Kipsoi et al., 2012; ↑Piper et al., 2015; ↑Wambugu et al., 2017; ↑Koomar & Blest, 2020; ↑Langthaler & Bazafkan, 2020; ↑Miller, 2020; ↑Mbogo, 2020; ↑Kaye, 2021). All these papers seem to acknowledge that technology could play a positive role in policy planning and the strengthening of Kenya's education system. For example, in their exploratory analysis of the barriers that hinder technology integration in education management in Kenya, ↑Kipsoi et al. (2012, p. 22) state that by collecting data with technology "administrators and policymakers can construct virtual scenarios around different policy options to determine needs and analyse potential consequences."

All eight papers also mention that there is limited evidence related to the use of technology to improve policy planning and strengthen education systems. ↑Piper et al. (2015), for example, argued that more research and evidence is needed, especially related to cost-effectiveness measures, to enable policymakers to use data to make informed system-level decisions related to EdTech. Two papers present indications related to technology playing a positive role in policy planning and the strengthening of Kenya's education system (↑Koomar & Blest, 2020; ↑Kaye, 2021). ↑Kaye (2021) mentions an online dashboard created as part of Tusome, which provides data for evidence-based policymaking, stating that "The data identified strengths and weaknesses which informed [...] system-level policy dialogue" (↑Kaye, 2021, p. 195). ↑Koomar & Blest (2020) also briefly mention that the data generated by Sauti za Wananchi could be used to support policymakers to identify educational needs.

In an exploratory study of digitalisation, education, and skills development in sub-Saharan Africa, ↑Langthaler & Bazafkan, (2020) express concern (to education experts) about the rapid growth of private EdTech companies in the region. According to the authors, these private entities have the potential to, "dislocate educational data collection, storage and processing out of the realm of public policy for commercial exploitation" (↑Langthaler & Bazafkan, 2020, p. 14). This suggests that it could be relevant for the Kenyan government as well as for EdTech researchers and implementers to consider the long-term impact of the growing influence of private EdTech firms. In an environment such as Kenya where technology's role in policy planning and the strengthening of the education system is relatively nascent, it could be relevant to consider how private EdTech companies can be encouraged to collaborate and / or share the data they generate and harvest with EdTech

researchers, implementers, as well as local, non-commercial, governmental agencies such as the MoE.

5.4. Technology to promote access and participation in school

Technology has the potential to provide education access to children who are out of school and to promote continuing education. It is also imperative to evaluate how EdTech can help to make up for the learning loss and potential school drop-outs caused by the Covid-19 pandemic, which may lead to children not going back to school even when schools reopen.

The research related to the use of technology for promoting participation in school in Kenya has focused on girls and access (n = 9), technology to motivate learners (n = 8), EdTech for children with special educational needs and / or disabilities (SEND) (n = 4), EdTech for refugees and displaced children (n = 1), and technology for out-of-school children (n = 4). Girls and access are covered in the next section (Section 5.5.), therefore, this section will focus on technology to motivate learners, SEND and access, and the use of technology for out-of-school children.

5.4.1. Technology to motivate learners

The literature presents significant agreements on the role and potential of technology to improve children's motivation to learn. All eight articles that discuss this theme reported that the use of technology in education positively impacts learners' willingness to learn and their motivation and / or curiosity with the subject matter (↑Wims & Lawler, 2007; ↑Ayere et al., 2010; ↑Odera, 2011; ↑Jesse, 2014; ↑Kisirkoi, 2015; ↑Amuko et al., 2015; ↑Chemwei et al., 2016; ↑Rugut & Role, 2013). For example, an empirical study that used surveys with head teachers, English teachers, and pupils in primary schools in Kisumu District — based on evaluating how radio can be harnessed in the teaching of English —reported that radio use was a factor that significantly contributed to children's motivation to learn English (↑Odera, 2011). According to the authors, the use of radio in English lessons, "stimulates thinking and imagination, because radio uses music and different sound effects to make learning enjoyable" (↑Odera, 2011, p. 965). Similar positive outcomes are reported for more high-tech devices. For example, an empirical case study of the integration of ICT in a boys' secondary school near Ngong town, Kajiado county, found that the majority of surveyed teachers (n = 30) reported that using computers in their classrooms "raised students enthusiasm, interest and creativity" (↑Kisirkoi, 2015, p. 1907). In addition, technology's potential to encourage learners retention in school is discussed in an empirical evaluation

of the impact of ICT in Kenyan educational institutions in which the authors state that technology's potential to motivate learners, "may deter children from dropping out" (↑Wims & Lawler, 2007, p. 71).

In light of this emerging evidence related to using EdTech to motivate learners, it is advisable for policymakers, researchers, implementers, and teachers to build on these preliminary findings to further define if and how technology could be effectively harnessed to motivate out-of-school learners, improve their learning outcomes and to increase school (re-)enrolment. This is also illustrated as a research gap, where more research could create a significant impact in supporting and guiding strategies and programmes to enable children to go back and remain in schools in Kenya, especially during or after Covid-19.

5.4.2. EdTech for children with special educational needs and / or disabilities (SEND)

Technology has the potential to widen participation in education so that learners with SEND benefit from more equitable learning outcomes and access to education. This idea is promoted by the vast majority of papers (n = 4) that discuss the theme of technology and access for SEND learners (↑Kaindio & Wagithunu, 2014; ↑Piper et al., 2016; ↑Mwendwa, 2017; ↑Ngari & Ndung'u, 2020)

The authors of an empirical study about the integration of ICT skills in Kenyan pre-school education write that "assistive / adaptive ICTs can reduce barriers to participation for children with special physical or learning needs" (↑Kaindio & Wagithunu, 2014, p. 91). This point is also made by the author of an empirical study about the availability of materials and facilities for EdTech integration within the public primary curriculum in Kitui County. The author states that EdTech could be used to enhance teaching opportunities and outcomes for learners with disabilities (↑Mwendwa, 2017).

Despite expressing the potential of EdTech for learners with SEND, within the search, no applied or empirical studies of technology improving access to education for learners with SEND could be found. In fact, the literature makes reference to technology not meeting this expectation, for example, ↑Piper et al. (2016) stated that "Though ICT applications have the potential to be adaptive for students with visual, hearing, physical, or developmental disabilities [...] they have not typically been designed for such usage in interventions in sub-Saharan Africa" (↑Piper et al., 2016, p. 205). The literature suggests that the situation has not improved since 2016, with a paper pointing to the lack of SEND provision in digital content made available during the Covid-19 pandemic. According to this exploratory study looking into the Kenyan

education sector's preparedness for the Covid-19 pandemic, within the schedule of educational television programmes aired during school lockdowns, they found that "No single program is catering to special education. The ones for regular learning should have sign language interpreters at least to aid the deaf" (↑Ngari & Ndung'u, 2020, p. 86). The literature emerging from the search demonstrates that in Kenya, technology's potential to improve educational access and learning outcomes for children with SEND needs and to increase education access to learners with SEND is only discussed and not yet empirically researched or evaluated.

5.4.3. EdTech for refugees and displaced children

The research revealed one study exploring the use of EdTech for refugees and displaced children (↑Joynes & James, 2018). An exploratory study based on looking at how EdTech has been used to improve learning outcomes for refugees and Internally Displaced People refers to the Instant Network Schools (INS) programme (↑Joynes & James, 2018) (see Section 4.2.8.). The INS, which is implemented by UNHCR, the UN Refugee Agency and the Vodafone Foundation, proposed 'Instant Classrooms' to learners living in refugee camps in countries where Vodafone operates. Each Instant Classroom is equipped with a laptop, 25 tablets preloaded with educational software, a projector, a speaker and a hotspot modem with 3G connectivity. According to the authors, each Instant Classroom can be set up in 20 minutes and they are designed to work in areas that lack electricity and internet connectivity (↑Joynes & James, 2018). An avenue for future research could be to explore the outcomes and impact of this programme and build on these findings to shape EdTech intervention to effectively improve learning outcomes for refugees and displaced groups in Kenya.

5.4.4. Technology for out-of-school children

The research revealed four papers that recognised the key role that technology can play in the education of out-of-school children (↑Trucano, 2005; ↑Tonui et al., 2016; ↑Jordan & Mitchell, 2020; Ng'ang'a et al., 2020). According to an empirical study that proposes a model for the implementation of web-based learning in secondary education in Kenya, EdTech could be used to "reach students who are unable to attend classes in a classroom environment because of time or distance constraints" (↑Ng'ang'a et al., 2020, p. 24). This idea that technology opens education opportunities to children who are classed as out of school is also presented in an empirical study into teachers' perceptions of ICT as a tool for curriculum management. The authors refer to a paper authored by ↑Trucano (2005), which asserts that "ICTs can be used to open educational opportunities to students and individuals who are strained from

attending institutions of learning" (↑Tonui et al., 2016, p. 15). Within the search, another example of technology for out-of-school children was found, called Eneza Education. Eneza Education provides a mobile-phone-based educational platform called Shupavu291 (↑Jordan & Mitchell, 2020). Shupavu291 is introduced as a programme intending to provide educational content through SMS to out-of-school children. However, no empirical study exploring its outcomes or impact on out-of-school children was revealed in the search, which presents an avenue for potential empirical research.

It is also important to consider that some Kenyan remote and / or marginalised communities do not have access to certain devices and / or to electricity, suggesting that for many of them, technology remains a distant idea. According to ↑Haßler et al. (2020) "Despite some initial optimism, emerging evidence from low-income countries indicates that few children are using EdTech to learn during the current pandemic" (↑Haßler et al., 2020, p. 6). The authors refer to only 22% of children in Kenya having access to digital learning materials during the Covid-19 pandemic. ↑Ngari & Ndung'u (2020) presented additional discussions related to this topic by exploring the shortcomings of digital provision during the Covid-19 pandemic in Kenya. Their study revealed shortcomings related to infrastructure to access technology and / or the internet as well as poor and unrealistic instructional design of digital materials. These findings and increasing evidence related to technology access emerging during Covid-19 could be used to further assess and find solutions related to enabling out-of-school children to access and benefit from EdTech. These, as seen above, could require further efforts in aligning EdTech interventions to local realities as well as improvements in infrastructures and instructional design of digital materials in Kenya. As suggested in this section, these interventions could involve exploring the use of EdTech to provide educational material to out-of-school children, encouraging them to go to school and / or support their re-enrolment in schools (for example, with access to remedial digital learning material).

Lastly, no papers exploring or discussing the use of positive messaging to encourage children to go back to school were found in the search. This suggests that there is a research gap related to exploring how to use positive messaging to (re-)enrol children in school in Kenya, and especially after the Covid-19 pandemic. This gap could be filled by providing research and empirical studies aiming at assessing approaches to directly guide children back to school, to receive support for sending children to school, and other approaches to encourage parents and their children to participate in school-based education.

5.5. Girls education and technology

In many countries, girls often do not benefit from the same education opportunities as their male counterparts. Enabling more girls to access education can have a significant impact on reducing economic and social inequalities — and equitable provision of technology can result in improved learning outcomes for girls. The potential impact of girls' engagement with EdTech indicates that it should be considered an important topic to be investigated through research.

The search found that 9 papers explored the theme of using technology to improve access to education and increase learning for girls (↑Wims & Lawler, 2007; ↑Kiptalam & Rodrigues, 2010; ↑Redempta, 2012; ↑Kiptalam & Rodrigues, 2013; ↑Jukes et al., 2017; ↑Wambugu, 2018; ↑Allier-Gagneur et al., 2020; ↑Langthaler & Bazafkan, 2020; ↑Allier-Gagneur et al. (2020). There are two sub-themes covered by the 10 papers, namely, girls' access to EdTech (n = 7), and the use of technology to improve learning outcomes for girls (n = 4). These categories are not mutually exclusive, as in some cases, papers included one or more of these categories.

5.5.1. Girls' access to EdTech

Most of the studies that discuss girls' access (n = 7) indicate that girls do not benefit from the same access to Edtech as their male peers (↑Wims & Lawler, 2007; ↑Kiptalam & Rodrigues, 2010; ↑Redempta, 2012; ↑Kiptalam & Rodrigues, 2013; ↑Zelezny-Green, 2014; ↑Wambugu, 2018; ↑Allier-Gagneur et al., 2020; ↑Langthaler & Bazafkan, 2020). For example, an empirical study that was based on surveys conducted with students, teachers, and principals of 11 secondary schools from Nairobi and Rift Valley provinces, indicates that levels of use of computers were lower for girls than boys, both in school and outside of school (↑Kiptalam & Rodrigues, 2013). This study drew on a study conducted by a consultancy called SchoolsNet Kenya, which found that girls' schools had nearly a third fewer computers than boys' schools in Kenya (↑Kenya Schoolnet, 2003; ↑Kiptalam & Rodrigues, 2013). In addition to the number of computers in schools, this study also presented findings related to disparities in how computers are used in schools, suggesting that in boys' schools the computers are mostly used by the students, whereas in girls' schools they are mostly used for administrative tasks (↑Kiptalam & Rodrigues, 2013). This finding, related to potential gender disparities in how computers are used in Kenyan schools, is introduced as a topic for future research. It also illustrates the need to avoid measuring access to EdTech with a singular approach, consisting of counting hardware devices in schools, and the need to investigate how devices are used and by whom — and the extent to which they could be used to improve learning outcomes.

This study also compares technology access in private and public schools as well as between rural and urban settings for girls and boys and it found that gender disparities in technology access are the highest in public schools in rural areas in Kenya (↑Kiptalam & Rodrigues, 2013). It illustrates that in public schools, 41.2% of girls had regular internet access at school compared to 89.2% of boys. This study not only provides further evidence that potential disparities in access to EdTech are influenced by contextual and socio-economic factors, it also demonstrated that even when girls and boys attend the same schools, gender disparities in access to technology could be found. These findings also suggest that more research that explores girls' EdTech access in schools across different settings and contexts in Kenya is needed to design and implement equitable EdTech interventions.

An empirical study that used surveys with various different stakeholders in secondary schools in 2007 found that inequalities related to EdTech access also existed outside of school environments (↑Wims & Lawler, 2007). The study found that outside of school, 30% of girls reported being able to access computers for educational purposes compared to 50% of their male peers (↑Wims & Lawler, 2007). Building on these findings, a similar study was conducted during Covid-19 (↑Twaweza East Africa, 2019). This study was based on household surveys conducted in 86 out of 335 sub-counties in Kenya and across 42 of the country's 47 counties. According to this study, 22.1% of boys compared to 22.2% of girls accessed digital learning materials during the Covid-19 pandemic (↑Twaweza East Africa, 2019). Further investigation could build on this research by looking into potential disparities in learning outcomes and / or explore the factors that have contributed to reducing this gender gap and support equitable access. As Kenyan learners were asked to study at home during the Covid-19 pandemic, it could be relevant to understand the potential role that family members, parents and caregivers, and teachers played in enabling boys and girls to equally access EdTech during the pandemic, as well as exploring the potential opportunities and barriers that they faced.

5.5.2. Use of technology to improve learning outcomes for girls

Using technology to improve learning outcomes for girls is discussed in four papers (↑Zelezny-Green, 2014; ↑Jukes et al., 2017; ↑Wambugu, 2018; ↑Allier-Gagneur et al., 2020). These include a literature review conducted by ↑Allier-Gagneur et al. (2020), where the authors touch on the positive role that mobile phones can play in girls' education and as part of EdTech intervention that could be used to improve learning outcomes for girls. They refer to a study by ↑Zelezny-Green (2014) that discusses how female students use their mobile phones to call peers to discuss and collaborate on assignments. The authors

state that "This type of collaboration, which can take place at any time, allowed them [girls] to create connections between formal learning in the classroom and informal learning" (↑Allier-Gagneur et al., 2020, p. 13). The potential role of mobile phones and collaborative learning opportunities for girls' education is also explored in a mixed-methods empirical study about the impact of the Health And Literacy Intervention (HALI) (↑Jukes et al., 2017). HALI was a project that sought to improve the literacy outcomes of schoolchildren, to reduce their burden of Malaria and to investigate the interaction between these two objectives. Among other activities, the project involved the use of mobile phone messaging to encourage teachers to provide literacy and collective support to students, and focuses on rural government primary schools in Kwale and Msambweni districts. The findings of this study illustrate that this mobile phone intervention had a more significant impact on the attainment of girls than boys in most areas of learning. According to the authors, "At 24 months, greater beneficial effects were observed for girls in English word identification [...], English passage-reading fluency [...] and Swahili passage-reading fluency" (↑Jukes et al., 2017, p. 21). Given these outcomes, there is a need for further research investigating why certain devices such as mobile phones used during EdTech interventions appear to contribute to creating a greater impact on girls' attainment, and what the additional factors that contributed to these findings are.

The literature reviewed suggested that a clearer understanding is needed of the factors that affect potential gender disparities in EdTech use, both at home and in school environments in Kenya. These factors could be used to design EdTech interventions that promote equitable learning outcomes for girls and boys. The literature search also revealed the necessity to include data related to girls' EdTech access and learning outcomes across different Kenyan contexts and settings, for example in urban and rural contexts and / or in public and private schools. There is also a need for research into the use of technology to improve learning outcomes for girls and nascent evidence about the suitability of mobile phones indicates that particular attention should be paid to ascertain how, why, and under what conditions using these devices can contribute to creating a positive impact on girls' attainment.

Overall, it was also found that limited research exists on the use of EdTech to implement back-to-school campaigns or to improve attendance and retention of girls at school. As the dropout rate of female students in Kenya is high[1] and is likely to be amplified due to Covid-19,[2] such research would be beneficial to

[1] While current statistics are not available at the time of publication, previous datasets from the Kenya National Bureau of Statistics indicate that the rate of dropout for secondary girls is over 50%.

[2] While this is reported from anecdotal and emerging global evidence (see for example ↑Malala Fund, 2021, indications from interviewees confirms this emerging trend.

stakeholders seeking evidence-based strategies to enable girls and boys to have access to equal and egalitarian EdTech opportunities.

6. Summary of political economy analysis

The purpose of this Political Economy Analysis (PEA) summary is to give a clear understanding of:

- which organisations and people are important to EdTech evidence uptake;
- why those bodies and people are important;
- how EdTech decision-making is linked with EdTech Hub focus' areas;
- how EdTech evidence is used (and opportunities for it to be used more);
- what are the most important aspects of education research in Kenya to ensure uptake, policy change, and impact over the next five years.

The analysis has combined desk-based research with anonymous and informal interviews with five influential individuals (referred to as participants) in the Kenyan education system including government, researchers, and NGO implementing partners. The analysis specifically looks at:

- The government education system (as opposed to private alternatives);
- Primary and secondary levels;
- The role of evidence in relation to EdTech;
- The political economy at this point in time, with particular emphasis on national changes to the EdTech landscape after the 2016 elections.

The EdTech ecosystem in Kenya is dynamic and decentralised due to the many departments and commissions within the Ministries of Education and ICT, the relatively large scale of tech startup investment relative to neighbouring economies, and the dynamic non-profit sector deeply involved in education. In interviews, this has been characterised as 'fragmentation' especially with regard to research, since the diverse decision-making bodies act independently, with little coordination and limited centralised control.

Within this context, stakeholders inevitably have different priorities and interests in research and EdTech. This section, building on the basic information presented in the context of Section 2, does not exhaustively represent the full breadth of interests but serves primarily as an introductory overview to the dynamics that inform research uptake in policy and practice.

6.1. Drivers of EdTech decision-making

The range of actors involved in EdTech in Kenya has been mostly broadened by political goodwill to specifically promote access to devices in schools. While this process has reflected a positive attitude towards technology adoption and integration, it has also broadened EdTech decision-making from the purely operational and pedagogical considerations which have governed it, into a political domain attracting much broader attention. Nonetheless, the structures in place, both economically and politically, continue to influence the implementation of EdTech initiatives on both a micro and macro level.

6.1.1. Government priorities and initiatives

Government involvement in EdTech falls under both the MoE and the MoICT, each of which has a number of autonomous and semi-autonomous commissions, institutes, and programmes. The most repeatedly mentioned by interviewees were the KICD, TSC and NACOSTI (National Commission For Science, Technology & Innovation). Yet dozens of other ministerial bodies govern and influence different aspects of policy and practice, making a joined-up approach and strategy virtually difficult.

Where priorities of governmental stakeholders are operational and internally driven by educational exigencies, they maintain some strategic coherence, despite the breadth of services offered. This can be seen in the broad digitalisation efforts of curriculum and administration. In any educational system, the competing interests of teachers, schools, and administrators can lead to friction, but in Kenya, the sheer volume of governmental bodies, not to mention their differing structures and operational realities, complicates these issues even further. There have also been successive waves of decentralisation and recentralisation of authority over the last decade, which seem to contribute to a lack of clarity around how EdTech decisions are taken and by whom.

6.1.2. NGOs

The NGO or third sector is very active in Kenya, which often serves as a regional base for international organisations involved in education in multiple countries in East Africa. This inevitably means that education programming in Kenya is not solely the preserve of the government, but is also influenced by the priorities and agendas of internationally-funded organisations. While school-based educational programmes must meet standards set by the government, a large number of educational initiatives beyond formal schooling are set by supplementary educational initiatives. These are not

necessarily at odds with the national priorities but they may be isolated or fragmented from larger strategies and policies.

Specific programmes and projects funded by NGOs have been presented in Section 4.2., but from the perspective of a PEA, the role of significant donor-funded initiatives that support these, such as the Global Partnership for Education (GPE) and Girls' Education Challenge (GEC), can be further highlighted.

6.1.3. Tech sector

Kenya is a hub for innovation and investment in technology within the region, and in this crowded marketplace of new ideas, education is among those receiving significant attention. This can be seen in the number of EdTech startups in incubator and accelerator programmes like C4D Lab, iHub, and mLab. The internal market for applications and services that supplement existing learning (primarily aimed at parents), is only the first consideration for such growth-minded startups, as they consider a broader international audience. This leads to the clustering of ideas around the perceived needs and gaps in existing education, but also to an emphasis on scalable and (sometimes) profitable interventions.

Additionally, a particular gender lens may be noted in the success stories of the tech sector in Kenya, some of the most successful tech entrepreneurs have been women, such as Ushahidi founder Ory Okolloh-Mwangi and Linda Kamau of AkiraChix. Through coding education programmes such as AkiraChix, Akili Dada, and Kami Limu, as well as prominent academics such as Chao Mbogho, dean of Kenya's Methodist University's school of computer science, there is a notable emphasis on female participation in the tech sector.

6.2. Research priorities

Priorities for EdTech research in Kenya are largely determined by demonstrating an evidence base for a particular intervention or programme. This has come out of and contributed to the fragmentation of the ecosystem, as there is no clear local or national mechanism for strategic alignment of different research priorities. National research bodies and research approval processes are underfunded and overstretched, making the aggregation or comparison of data from different studies very difficult. Few broad evidence syntheses have been undertaken and what little there is relies on research produced outside of Kenya.

6.3. Partnerships and scaling

Kenya presents a unique set of opportunities and challenges with regard to EdTech — the strong government buy-in and vibrant tech ecosystem suggest high potential for growth and scaling. Indeed several technology interventions have already demonstrated growth, and impact on development outcomes has already been identified in such everyday applications. Despite the relative success of many programmes and interventions mentioned in Section 4.2., especially in the case of partnerships, such as Tusome and Uwezo, iterative stages of growth and scaling have been limited. Interviews with implementing partners from the private and third sector suggest that limited understanding of government requirements for engagement which touches on curricular issues has led to a backlog of suitability testing, an important tool in maintaining oversight of third-party interventions. Clear processes for partnering with the government could effectively lay the groundwork for partnerships between stakeholders, with great efficiency and diversity of input.

7. Emerging priorities and opportunities for collaboration

In this review, we have drawn on a range of sources — including contextual statistics, policies, political economy analysis, and the existing research literature — to present an overview of the landscape of EdTech research in relation to school-level education in Kenya. Although progress has been made in improving access to education, inequalities exist, for example in relation to socio-economic lines, urban and rural contexts, and gender (Section 2). Kenya has an established and growing community around EdTech research (Section 4). As a result, we were able to draw on a substantial body of existing research literature (Section 3) and explored mapping the literature onto EdTech Hub's focus themes (Section 5). Finally, we explored the influential actors and dynamics in relation to education and technology within the Kenyan educational system through PEA (Section 6). The importance of coordinating research was underscored through the interviews which informed the PEA, as the importance of new research building on existing research was seen as difficult to realise without adequate coordination between research bodies. Considering both gaps, which emerged in Section 5, and the practicalities of the operating context outlined in Section 6, we have identified five areas as being potentially valuable focal points for EdTech Hub and its future work.

7.1. Technology to support personalised learning and teaching at the level of the student

Personalised learning was the area with the least demonstrated evidence in the EdTech literature, and research on this area is limited. The relatively low cost of devices and airtime, as well as the mature mobile ecosystem, combined with the emphasis on rolling out personal devices in classrooms, suggests that the use of personal devices among students will be higher in Kenya than in similar economies. This presents a greater opportunity for personalised learning with personal devices but remains a speculative possibility for the most part. Reviewing the literature on this topic (see Section 5.1.) revealed a gap related to understanding how technology can be used most effectively to personalise learning in an effective, cost-effective, and contextually appropriate way in Kenya. In addition, it was also found that the role of teachers in making technology-supported personalised learning effective has also received limited attention. This is in addition to research needed to explore whether (and if so, how) personalised approaches that

feature technology adapting or adjusting to learners' individual needs are effective in leading to better learning outcomes.

7.2. Teacher professional development, structured pedagogy, and technology

The focus area covered in most depth by the EdTech literature in Kenya is TPD, with 35 papers on the subject — demonstrating the significant attention this area has within the EdTech ecosystem in Kenya. Reviewing the literature on this topic (see Section 5.2.) demonstrated the weight of expectation that technology can be a catalyst for improving teaching quality, which Piper, et al. (2017) highlight as the biggest challenge in the educational system. However, the evidence in the literature points to a gap between understanding teachers' perceptions and attitudes to technology (covered in 6 studies) and their competence with technology to improve children's learning outcomes (16 studies). Future research could look into joining these research topics and generate robust evidence around the drivers and factors that could improve and promote changes in pedagogical practice with EdTech. The research opportunity to understand the mechanisms for change in teaching practice would complement existing research while also building bridges between the significant investment already made in researching EdTech for TPD in Kenya. Our literature review also revealed the need to use evidence to inform initiatives and investments intending to upskill teachers' digital literacy. Lastly, it was also found that the ongoing, continuous nature of TPD tended not to be acknowledged or built on in the studies found. We consider this as an important opportunity for future research as it could contribute to sustainably improving teaching practices and children's learning outcomes in Kenya.

7.3. Technology to advance data-use and decision-making in education

The use of technology for data-driven decision-making was the area with the second most attention in the literature, after teachers. The strong emphasis on technology in schools as a governmental priority has largely been politically driven and is focused on personal devices. Yet, for this to be rolled out, data systems to join up these devices is of paramount importance. Data collection with mobile devices has an iconic place in Kenya since the role of the reporting platform Ushahidi in the 2007–8 post-election crisis. The Tusome programme was introduced as a successful case study where various strands of activity related to using handheld devices for data collection and analysis were implemented, which also included school-level data and national and local mechanisms to analyse and use data. This programme and its related findings

could be used as emerging evidence to inform future research, as moving beyond data collection, and towards data use and analysis is presented as a key research priority in Kenya. Despite the significant interest in this topic for the EdTech research ecosystem in Kenya, the drivers of change, and the analysis of how data can inform decision-making need to be better understood. Further rigorous qualitative research on these mechanisms presents an opportunity for maximising the benefits of the other research undertaken. This research could be used to further understand how technology could be used to improve policy planning and strengthen education systems, which also emerged as a gap in the literature reviewed.

7.4. Technology to promote access and participation in school

Kenya's emphasis on universal primary education has led to great gains in access, however, issues related to enabling out-of-school and hard-to-reach populations to access education still exist. This is particularly true among the rural pastoralist communities of north and northeast Kenya, as well as the very large and mobile refugee populations. The literature reviewed (see Section 5.4.) revealed very limited evidence related to understanding how, if, and / or the extent to which technology could be used to deliver high-quality, contextualised, and cost-effective education to out-of-school refugees / displaced children in Kenya, and those with SEND. While there has been no specific research on using technology to nudge messaging to increase participation and sustain school attendance, the use of mobiles to disseminate important messages among communities with high rates of children out of school demonstrates the possibility for future research in this regard.

7.5. Girls' education and technology

Girls' education is a major priority for donors and governmental entities in Kenyan education (↑GPE, 2020). The employment opportunities recognised within the tech startup sector are held up as an opportunity for successful transitions for girls from education to employment (see Section 6.1.3.). The literature reviewed (see Section 5.5.) suggested that there is a research gap related to understanding drivers that affect potential gender disparities in EdTech use in Kenya, both at home and in school environments (including urban and rural contexts and / or in public and private schools). It was also found that limited research exists on the use of EdTech to implement back-to-school campaigns or to improve attendance and retention of girls in school. Conducting such research could be beneficial to stakeholders seeking

evidence-based strategies to enable girls and boys to have access to equal and egalitarian EdTech opportunities.

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9. Annexes

Annex A: Search terms

Two sets of search terms facilitated searches.

Set 1 (title, abstract, and keyword searches only):

Kenya AND

EdTech OR “Education technology” OR “technology enhanced” OR “e-learning” OR “computer-assisted” OR “computer-supported” OR “computer-aided” OR “blended learning” OR “distance learning” OR “digital learning” OR ICT4D OR “Intelligent tutoring system” OR “adaptive learning” OR “mobile learning”

Set 2:

“Kenya” AND

Education OR Learning OR Teaching OR Classroom AND

EdTech OR technolog* OR Digital OR Remote OR Internet OR “Social Media” OR “Distance learning” OR Online OR Mobile OR Phone OR Virtual OR Laptop OR Tablet OR comput* OR televis* OR Device OR Software OR MOOC OR ICT OR Video OR radio OR “blended learning” OR e-learning OR “management system” OR “LMS” OR VLE OR SMS

Annex B: Additional EdTech projects

EdTech projects that were not discussed in empirical studies or evaluation research:

Eneza Education

https://enezaeducation.com/

Eneza is based on offering a feature-phone-based learning platform that enables users to access educational programmes and ask questions to teachers through SMS. This platform is targeted at learners and teachers living in rural and marginalised communities in Kenya where challenges related to accessing educational resources were reported.

Ubongo

https://www.ubongo.org/

Ubongo creates localised and multi-platform educational media, facilitated through TV, radio, YouTube, mobile app, ebook, interactive voice response (IVR). Ubongo is an edutainment company that intends to create accessible EdTech tools, mostly targeted at improving reading skills and promoting social and behavioural change for children, caregivers, and educators.

e-Limu

https://e-limu.org/

e-Limu is a mobile application that intends to facilitate learning outcomes related to literacy development through videos and games. e-Limu's main target audiences are primary school learners and refugees but it also provides applications for teacher training.

eKitabu

https://www.ekitabu.com/

eKitabu is based on creating low-cost, accessible, quality digital content facilitated through mobile or web apps. Their target end-users are primary and secondary learners and learners with special needs.

Kukua

https://www.kukua.me/

Kukua is based on offering educational mobile games to teach literacy and maths skills to primary school learners. Some of these games can be played on mobile or web applications, on Youtube and TV.

Longhorn Publishers: e-Learning Platform

https://elearning.longhornpublishers.com/

The e-Learning platform is targeted at delivering personalised e-Learning items in various digital formats to primary and secondary school learners. These digital formats include Web app, mobile app, SMS, and YouTube channels.

M-Shule

www.m-shule.com

M-Shule is an adaptive, mobile learning management platform intending to improve learning performance of primary school students across Kenya and sub-Saharan Africa.

Arifu

http://www.arifu.com/

Arifu is a chatbot platform for improving learning outcomes and engaging, training, and capturing insights on hard-to-reach learners, who do not have access to the internet.

Tunapanda

https://tunapanda.org/

Tunapanda institute's objective is to bridge digital divides. As part of this initiative, TunapandaNET is a low-cost community wireless network whose goal is to build a digital ecosystem in education, health, and business. Tech Dada is another programme of the Tunapanda Institute which aims to promote digital inclusion for young women in Kenya.

Annex C: EdTech Hub Sandbox in Kenya

EdTech Hub has implemented systematic experimentation in the form of what is called a *sandbox* in Kenya. A sandbox is a real-life location used for experimentation and creates a small and contained space to test with a proposed intervention. It allows us to safely learn and adapt in a small space before rolling out promising ideas more widely.

The problem this sandbox addresses

Covid-19-related school closures have impacted hundreds of thousands of learners in Kenya and are expected to lead to significant learning loss. This is particularly true for the most marginalised learners, who may not have access to any distance learning resources or instructional materials.

The goal of the #KeepKenyaLearning (KKL) campaign is to set clear expectations for parents and caregivers of what learning at home should look like, and provide them with access to digital and non-digital resources to support those learning experiences. Leveraging a wide network of over 30 Kenyan EdTech providers and community-based education organisations, this campaign will curate learning content, disseminate it to caregivers through

both on and offline channels (TV, print, radio), and foster a conversation that will allow parents and caregivers to showcase innovative ways in which they are supporting learning at home.

What EdTech Hub is doing

EdTech Hub and the leaders of KKL are in the early stages of this sandbox (as of May 2021) and are identifying the areas that need exploration. These are likely to include:

- Understanding the needs and motivations of caregivers, and the extent to which they have the resources, time, and willingness to engage in their children's learning at home.
- Exploring the most effective ways to message the importance of caregiver engagement in education, as well as guidance on how caregivers can effectively engage.
- Exploring the most effective communication channels (SMS, WhatsApp, Radio, TV) for disseminating 'learning at home' resources for caregivers.

Learn more about this initiative here.